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Spacelab Level IV Programmatic Implementation Assessment Study

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FINAL REPORT

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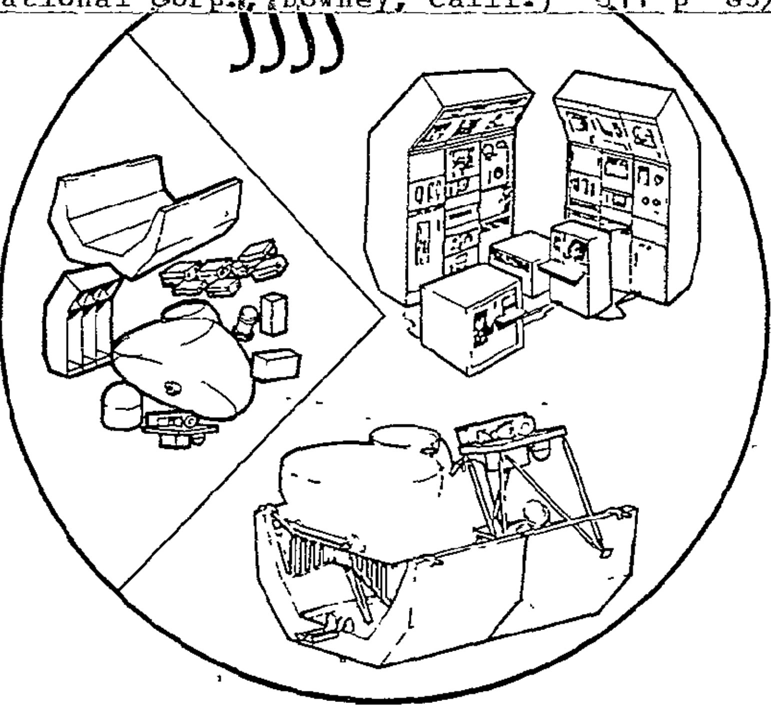

Volume III

Optimization and Programmatics

PREPARED UNDER CONTRACT NO. NAS1-14909

BY

Rockwell International

Space Division

FOR

NASA

National Aeronautics and Space Administration

LANGLEY RESEARCH CENTER

HAMPTON, VIRGINIA 23665

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A Gianformaggio
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Study Manager

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The study was initially directed by Mr. Larry Hogan and subsequently by Mr. Antonio Gianformaggio. Major contributions were also given by the following Rockwell personnel:

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FOREWORD

The Spacelab Level IV Programmatic Implementation Assessment Study was conducted to assess the Level IV payload integration requirements. In the study, alternate Level IV integration approaches were synthesized and evaluated to establish the most cost-effective experiment integration approach. Resource requirements or cost factors that were included in the assessment pertained to the "hands-on" activities of ground processing. These requirements included manpower, temporary duty subsistence and air fare, flight hardware and GSE transportation costs, and prorated flight hardware and GSE use costs based upon the involvement time of these items for each mission. Programmatic inventories of flight hardware and GSE were developed using representative payloads. These payloads were defined to a level of detail that permitted a detailed assessment of the handling, installation, servicing and checkout requirements of the experiment end items. Spacelab flight hardware and GSE support and interface requirements were identified. Buildup schedules for the inventories were formulated. Alternate ground processing concepts were synthesized and the processing of each of the representative payload through these concepts was evaluated. Cost data for each processing option was developed for each payload. The spectrum of experiments and payloads used in the study facilitated the identification of design characteristics to identify the ground processing activities. Guidelines were identified to assist experimenters in the development of payload designs that will permit cost-effective ground processing.

The results of the Spacelab Level IV Programmatic Implementation Assessment Study effort are presented in four volumes:

VOLUME I	REPRESENTATIVE PAYLOAD DEFINITION	SD 78-SR-0009-1
VOLUME II	GROUND PROCESSING REQUIREMENTS	SD 78-SR-0009-2
VOLUME III	OPTIMIZATION AND PROGRAMMATICS	SD 78-SR-0009-3
VOLUME IV	EXECUTIVE SUMMARY	SD 78-SR-0009-4

CONTENTS

CONTENTS (CONT'D)

CONTENTS (CONT'D)

CONTENTS (CONT'D)

ILLUSTRATIONS

ILLUSTRATIONS (CONT'D)

ILLUSTRATIONS (CONT'D)

ILLUSTRATIONS (CONT'D)

TABLES

TABLES (Cont'd)

TABLES (Cont'd)

TABLES (CONT'D)

TABLES (CONT'D)

TABLES (CONT'D)

1.0 INTRODUCTION

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Volume III Optimizations and Programmatics contains the results of the System Trade Studies (Task 5.0), the Spacelab Programmatic Assessment (Task 6.0), and results of the Traffic Model Variations (Task 7.1).

Three major system level trades were conducted in Task 5.0. They were performed to establish the most cost effective approach for each of the three ground processing concepts developed in Task 4.0 for each representative payload. The use of simulated (Subtask 5.1) and dedicated (Subtask 5.2) Spacelab equipment was evaluated and the results presented in section 2.0 entitled "Program Baseline-System Trade Studies". Programmatic considerations were evaluated by the synthesis of experiment and payload reflight schedules and by assessing their potential effect on flight hardware utilization and allocation. The cost, hardware requirements - both Spacelab flight hardware and Level IV integration GSE, implications of shared (progressive) Level IV integration of Spacelab flight hardware were evaluated. These results of the shared Spacelab equipment utilization trade (Subtask 5.3) are presented in section entitled "Shared Spacelab Equipment Utilization". The most cost-effective approach for each of the four representative payloads was selected from an analysis of the results of the trade studies. The selections and recommendations from each of the major trade areas is documented in section entitled "Approach and Concept Evaluation".

In Section 3.0 "Level IV Ground Processing Baseline Program", the extrapolation of the data generated for the four representative payloads to the entire Spacelab traffic model is discussed. The six viable ground processing options selected to be carried through the programmatics are discussed. "The Traffic Model" section defines the model analysis that was conducted to establish the numbers and types of Spacelab configurations and their launch dates. Section 3.0 defines the programmatic resource requirements for the Baseline traffic model only. Sections 4.0 and 5.0 discuss the resource requirements and costs for the 2/3 and 1/3 traffic models respectively.

An equivalency was established between the four representative payloads of the study and the 560 Mission Model. This data along with the launch dates for each Spacelab mission are developed and presented in section 3.0 on "Traffic Model Analyses". The resource requirements in the areas of personnel, Level IV Integration, Spacelab Flight Hardware, and Transportation costs are included in this volume in Section 3.0. Required inventories of Spacelab unique flight and ground equipment, simulators, and major common payload support items have been established and are documented in their respective sections of this volume. Also included are the "hands-on" manpower requirements at each involved Level IV integration center. Transportation and shipping requirements and costs were identified and reported along with a programmatic schedule and a summary of the composite ground processing costs for the four areas listed above. The results of the system level trades are factored into the programmatics data presented in Sections 3.0, 4.0, and 5.0.

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2.0 PROGRAM BASELINE - SYSTEM TRADE STUDIES

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A series of trades were conducted to determine the cost cost-effective approach for each of the ground processing concepts developed for the representative payloads. These trades included the use of simulated or substituted Spacelab unique equipment for such items as RAU's, IPS, SIPS, Spacelab module floor, cabling, pallet freon pump and the pallet inverter. Both dedicated and simulated Spacelab unique equipment were also included in the trades.

Other programmatic considerations were introduced by synthesizing experiment and payload reflight schedules and assessing their effect on the hardware utilization and allocation. Cost and schedule implications of progressive Level IV integration of shared Spacelab flight hardware were developed. The results of these trades were used to determine the most cost-effective Level IV integration approach for each of the representative payloads.

SUBSTITUTED SPACELAB EQUIPMENT UTILIZATION

The baseline Ground Processing sequences and cost data are based on the assumption that all the Spacelab equipment, with the exception of the Igloo and the Spacelab Module shell, are available at the Level IV integration site. An alternate approach was also analyzed wherein the use of simulated or substituted Spacelab equipment was used to determine if savings in overall costs would result or offset the added costs of the substitute equipment.

The savings which may accrue can be substantial. Flight hardware is limited in quantity and any reduction in the involvement time by using substituted or simulated equipment reduces the number required, thus reducing program cost.

For example, if a substitute RAU would be used during installation and verification of experiment equipment, and the actual flight RAU were later installed during Level III activity at KSC, the flight RAU would be free to support other missions during this time. Any savings would be offset by the cost of producing a substitute RAU with the same electronic capabilities, as well as the cost of removing the substitute RAU and installing the flight RAU at KSC.

The most cost-effective approach for each item of Spacelab equipment has been identified and is found in the subsequent section entitled "Conclusions and Recommendations" of section 2.0. This can then be factored into the baseline to determine changes in the integration costs of flight hardware proration.

Criteria for Candidate Selection

The following criteria was established for the selection of candidate Spacelab equipment which could or should be substituted or simulated:

(a) High Capital Cost. Items of Spacelab equipment which are especially expensive stand to benefit the program the most by substitution. This is true because the lowered involvement time resulting from substitution results in lower costs per flight for the flight equipment.

(b) Low Utilization in Level IV. Equipment supplied at Level IV which is really not needed, or needed very little, during Level IV integration, can easily be replaced with substitute hardware to reduce involvement time of the flight hardware.

(c) Low Risk for Deferred Verification. When nonflight substitute equipment is used in Level IV integration, verification of the functional operation of the equipment and its interfaces with experiment and subsystem equipment must be deferred until the flight equipment is installed in a later level. This entails a risk of schedule delays if verification is not immediately successful. Therefore, equipment items which have inherently lower risk of problems in interface/functional verification are better candidates for substitution.

During the development of the above criteria, it became evident that criteria could be developed to exclude equipment from substitution or simulation:

(a) Spacelab Subsystem Equipment Not Available in Level IV. Many items of subsystem equipment are not available for Level IV integration. These include the Igloo, Spacelab module CRT-keyboard and the Spacelab module heat exchanger. Since these are not present and not used at Level IV, substitution is not possible.

(b) Spacelab Equipment Required in Level IV. Equipment which serves primarily as structural support for experiment equipment, such as racks and pallets, must be used in the flight configuration in order to accomplish the goals of Level IV integration. Substitution of non-flight equipment would only necessitate later removal from the substitute hardware and repetition of the Level IV installation task. Such equipment was, therefore, considered not eligible for substitution.

Candidates Selected for Substitution Analysis

As a result of the application of the criteria discussed above, the following items of Spacelab equipment were selected for detailed analysis.

(a) Instrument Pointing Subsystem (IPS) - This equipment is considered a prime candidate for substitution at Level IV. It involves very high capital cost (approximately $20 million), very limited availability and minimal use during Level IV activities. The IPS, being incapable of actual operation in a one-G field, could only be partly checked out after integration.

(b) Small Instrument Pointing System (SIPS) - This equipment, similar to the IPS, is an excellant candidate for substitution; the high capital cost ($8 million not including experiment canisters), very limited availability and minimal use during Level IV activities makes substitution of a "non-flight SIPS" during Level IV very attractive.

(c) Module Floor Assemblies - The integration of the ATL and Life Sciences payloads at Level IV assumed that floors were available for mounting racks and routing of inter-rack cabling and fluid lines. Although floors are not extremely expensive, considerable savings in transportation appear possible, and there is low functional utilization (carrying of flight loads) in Level IV. Deferring the verification of the electrical and fluid interfaces until Level III/II activity at KSC could increase the risk involved of successfully completing the integration activities.

(d) Cabling and Fluid Lines - As noted above, the baseline approach assumed availability of flight floors (and pallets) allowing permanent installation of flight cabling and tubing. Whether or not substitute floor assemblies are used, flight cabling/tubing could be deferred to later integration levels where fewer connect/disconnect steps and reverifications would be required, and verification at Level IV performed using GSE substitute cable assemblies.

(e) Pallet Freon Pump - The Spacelab-provided Freon pump on the leading pallet frame of Space Processing and Combined Astronomy payloads is relatively expensive ($110,000 for the package including accumulator). More important, it is not mandatory that it be used in Level IV activities. In order to use the Freon cooling system during experiment checkout, a GSE Freon servicer must be connected to fill/bleed the system and connect it to a Refrigeration Unit (GSE) for heat rejection. These GSE items above can provide Freon circulation during operation, hence the Freon pump need not be present. A fluid jumper line is installed between the pallet and the Refrigeration Unit.

(f) Pallet Inverter (400Hz AC) - Like the Freon pump, the function of the inverter can be performed by GSE or facility power supplies connected to the system. Although AC connections to GSE are not essential (as Freon connections are in the case of the Freon pump), DC connections are needed to power the inverter, and AC can be supplied from a GSE motor/generator set or inverter. Hence the inverter can readily be replaced with GSE connections (no substitute unit is required) during Level IV activities.

Small Instrument Pointing System (SIPS) - Substitution Analysis

A scenario was developed in order to determine the potential savings in involvement time in the event there was a substituion for the SIPS. In the scenario, the Level IV activity consists of mounting a simulated SIPS on a simulated pallet and fabricating and installing the necessary cable assemblies. These assemblies are then shipped to KSC where they, along with the flight SIPS, are installed on the flight pallet during Level III activities. This sequence is depicted in Figure 2-1 for processing option A-1. In this option, the Level III activity is lengthened three days by adding a three day Block 10. In other options, where payload checkout is involved (Blocks 7, 8 and 9) such as Option A-2, this work can be integrated into those functions without an increase in overall time.

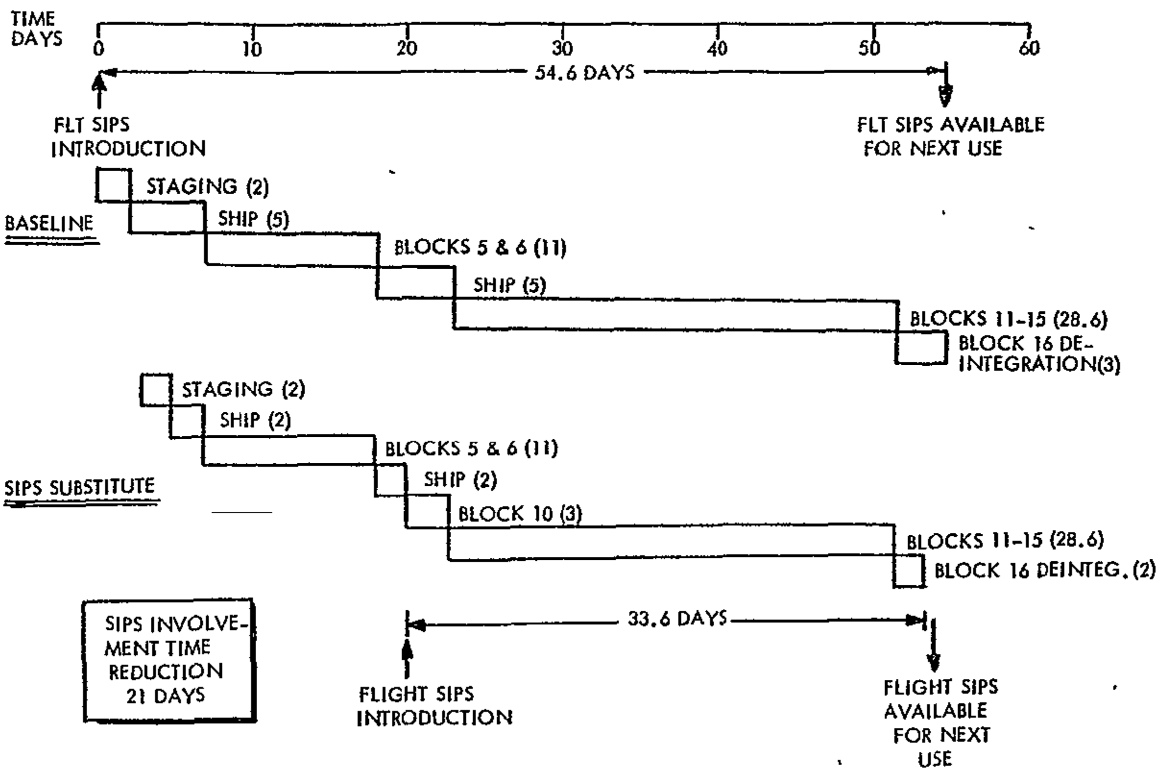

Figure 2-1. Substitution Trades Methodology (Simulated SIPS Interface)

The total SIPS involvement time, shown in Figure 2-1, is changed from the baseline 54.6 days (from mounting the SIPS on the pallet during staging to removal during deintegration) to 33.6 days (from mounting flight SIPS on flight pallet in Level III to the end of the abbreviated deintegration). The shorter period is due to shorter transportation times from KSC to integration site (lead center or mini-center) and back to KSC; and the deferment of SIPS installation until Level III integration at KSC. In the case

where this installation must be done in Level III, rather than during payload checkout (Blocks 7, 8 and 9), this additional 3 day effort offsets in part the savings in transportation time. Figure 2-1, representing the timeline for option A-1, does not include this additional savings.

In addition to reduced involvement time savings for the flight SIPS and pallet, various other factors are affected. These include reduced deintegration effort, increased TDY for PI support at KSC during Level III, increased GSE cost based on the prorated cost of a substitute SIPS, decreased GSE involvement time, and increases/decreases in transportation cost which balance each other. These are summarized in Table 2-1, Sample Cost Derivation, which shows a net savings for all cost factors of $34,950 for the A-2 Processing Concept.

Table 2-1. Sample Cost Derivation - Deferred SIPS Installation - Concept A-2

	INCREASE	DECREASE
MANPOWER		
INSTALLATION & REMOVAL OF CANNISTERS FROM SIMULATED SIPS	9,400	
REDUCED DEINTEGRATION		600
TDY		
PI SUPPORT DURING SIPS/CANNISTER INTEGRATION AT KSC	3,200	
TRANSPORTATION		
SHIP TO/FROM LEVEL IV SITE (WIDE LOAD)		8,000
STANDARD SHIPMENT	6,000	
INTRA-SITE MOVES	2,000	
GSE	170	
SUBSTITUTE GSE		3,600
SPACELAB GSE (PALLET HANDLING & SERVICING)		1,440
SIPS GSE		
FLIGHT HARDWARE		
SIPS		9,600
PALLET EQUIPMENT		31,220
CANNISTERS		1,260
NET SAVINGS $34,950	20,770	55,720

Applying these factors to the other baseline processing concept options, differing amounts of increased and decreased costs were developed. These are summarized in Table 2-2. A review of these data show that significant savings are realized for all processing options with the exception of option C-1, which resulted in a net cost increase of $28,580. This option results in a cost increase because the involvement time of the remainder of the Spacelab equipment is increased 3 days by the assumed 3 day

SIPS/canister assembly activity in Level III. In the other options, this 3 day period was offset by the reduction in transportation times from 5 to 2 days (wide load vs. standard load). If this 3 day activity can be bypassed or paralleled with other activities, the C-1 option will also show a significant cost savings.

Table 2-2. Substitution Trade Summaries - Dollars

● SIPS TRADES	OPTION						
	A-1	A-2	B-1	B-3	B-5	C-1	C-3
MANPOWER	+8,800	+8,800	+8,800	+8,800	+8,800	+8,800	+8,800
TDY	+450	+3,200	+1,650	+1,650	+1,650	+530	0
TRANSPORTATION	-2,000	0	0	0	0	0	0
* GSE:							
SUBSTITUTE	+170	+170	+220	+280	+290	+150	+140
SPACELAB	-3,750	-3,600	-1,500	-1,920	-1,980	-780	-900
SIPS	-1,320	-1,440	-2,460	-2,720	-2,810	-480	-1,280
* FLT HARDWARE.							
SIPS	-8,800	-9,600	-10,000	-12,800	-13,200	-5,200	-6,000
PALLET EQUIP	-28,710	-31,220	-32,620	-41,760	-43,060	-16,970	-19,570
CANNISTER	-1,260	-1,260	-1,260	-1,260	-1,260	+630	-320
SL (ADDITIONAL DAYS)	0	0	0	0	0	+41,900	0
TOTALS ——	-36,420	-34,950	-37,170	-49,730	-51,570	+28,580	-19,130

NOTE:
* PRORATED COSTS
\- The dash represents the amount saved.

This analysis points out the importance of carefully examining the effect of deferring use of flight hardware to determine if additional downstream efforts created by the deferment may offset gains from reduced involvement time of Spacelab and GSE hardware. The differences in cost savings between concepts are primarily due to variations in the reduction of involvement times of the SIPS and its pallet. A transport savings of $2000 is affected in the A-1 concept because the transportation to the distributed site was reduced from a wide load to a standard load. In the other options, the SIPS/pallet was either part of a wide load, or an additional intersite move was required.

Figure 2-2 indicates that there is a net savings for each of the options studied with the exception of Option C-1. The added expense in Option C-1 is due to the additional involvement time of the Spacelab.

Instrument Pointing Subsystem (IPS) - Substitution Analysis

Applying the methodology, factor analysis and rationale that was used for the SIPS substitution, substantial savings were developed for the case of using a substitute IPS and pallet during Level IV. In this case, a simulated IPS would be used on a simulated Pallet 2 of the Combined Astronomy payload in Level IV to develop the flight cabling assemblies. As with the SIPS study, the cable assemblies would go to KSC where they, and the flight IPS, would be installed on the flight pallet and the combination checked out. Virtually all of the comments presented in the SIPS-Substitution Analysis case would apply here as well.

Table 2-3 presents the findings from this trade study, which results in net savings ranging from $246,920 to $347,510 for the five processing options studied. In contrast with the SIPS substitution trade, the IPS does not show savings in the areas of manpower, TDY, deintegration and transportation. Manpower does not decrease with the use of a substitute IPS because, even with the flight IPS, there is no electrical connection or operation of this zero-G equipment, and only a mechanical mounting is entailed in either case. TDY is unchanged because each option studied included Blocks 7, 8 and 9 where the deferred assembly would be accomplished without additional serial time and with PI personnel already covered by TDY for payload assembly/checkout work. Transportation is unchanged because a wide load is still necessary to transport the balance of the experiment - the SIRTF and pallets 3/4. Deintegration costs are unchanged because it was assumed that the IPS would be removed from the pallet during deintegration in the usual manner.

Table 2-3. IPS Substitution Trade Summaries ($)

- IPS TRADES

	OPTION				
	A-2	B-2	B-4	C-2	C-4
MANPOWER	-	-	-	-	-
TDY	-	-	-	-	-
IPS DEINTEGRATION	-	-	-	-	-
TRANSPORTATION	-	-	-	-	-
GSE:					
IPS & SUBSTITUTE	+7,490	+7,490	+6,890	+5,910	+5,320
PALLET	-3,230	-3,230	-2,980	-2,550	-2,300
FLT HARDWARE:					
IPS	-304,000	-304,000	-280,000	-240,000	-216,000
PALLET EQUIP	-47,770	-47,770	-44,000	-37,710	-33,940
TOTALS	-347,510	-347,510	-320,090	-274,350	-246,920

Module Floor - Substitution Analysis

In the ATL payload, installation of experiment ST-25 (Combustion Facility) involves complex installations of wiring, plumbing and a combustion chamber on one floor segment of the manned module. This normally would require the availability of the floor segment during Level IV integration. For this analysis, it was proposed that a substitute floor segment be available, in which the wiring and plumbing could be mocked up and fabricated in final form and the chamber could be test mounted for interface checkout and experiment testing. The cabling, plumbing and chamber would then be removed, shipped to the Level III location, and installed on the flight floor segment during either online Level III activities or during preparation for payload checkout, as applicable.

The same methodology for analysis was applied as in the previous studies, and the results are presented in Table 2-4 for processing options A-1, A-3, B-1, B-3, B-5, C-1 and C-3. As can be seen, there is actually a cost increase resulting from this substitution as compared to the baseline processing concept, although a negligible increase in most cases. This appears to be due to the cost of the substitute floor proration and the added manpower required to remove and reinstall cables, plumbing and chamber, all of which is not offset by the savings in flight hardware involvement. This fact, coupled with an increased risk of schedule impact from difficulties in the delayed integration, makes this substitution option rather unattractive.

Table 2-4. Floor Substitution Trade

- ATL PAYLOAD

	OPTION						
	A-1	A-3	B-1	B-3	B-5	C-1	C-3
• MANPOWER	+1000	+1000	+1000	+1000	+1000	+1000	+1000
• GSE	-	-	-	-	-	-	-
• TDY	-	-	-	-	-	-	-
• TIME - FLOORS	(-34d)	(-38.6d)	(-34d)	(-38.6d)	(-34d)	(-26d)	(-26d)
- SUBSTITUTE	(+29d)	(+33.6d)	(-29d)	(+33.6d)	(+29d)	(+27d)	(+27d)
• HARDWARE COSTS							
- FLT FLOORS	-816	-926	-816	-926	-816	-624	-624
- SUB. FLOORS	+116	+134	+116	+134	+116	+108	+108
- ATL SL HDWE	-	-	-	-	-	+3800	+3800
TOTALS	+300	+208	+300	+208	+300	+4284	+4284

Rack Cabling Substitution Analysis

The baseline Level IV integration scenario calls for the flight cabling, both power and signal, to be fabricated and installed into the Spacelab flight hardware at the Level IV site. An alternative approach would be to fabricate GSE cabling to be temporarily connected between racks to permit experiment interface verification and total payload checkout. The flight cabling would then be installed at KSC during Level III operations and the interfaces reverified.

The benefits of this alternate approach would be reduced exposure of the flight cabling to wear and tear, with corresponding improvements in reliability and replacement expense, which have not been quantified in terms of dollars. This analysis seeks to determine the cost of gaining this advantage, rather than seeking to show an overall cost benefit from this substitution.

Table 2-5 presents the cost analysis for this substitution. As this table shows, the cost of the cabling itself, the installation and removal manpower amounts to a cost increase of $40,730 for Life Science and $45,450 for ATL. It is assumed that the cabling must be designed and fabricated 'custom-made" for each payload, and therefore cannot be reused or prorated.

Table 2-5. Assessment of Substitute Cabling for Rack Interconnections

● LIFE SCIENCE PAYLOAD		
• GSE CABLE COST		
700 CONDUCTORS X $40/CONDUCTOR	= $ 28,000	
38 CABLES X $200/CONNECTOR PAIR	= $ 7,600	
• INSTALLATION COSTS		
(228 FEET) (0.25 HR/FT) (2 TECH) ($30/HR)	= $ 3,420	
• REMOVAL COST		
ONE HALF INSTALLATION COSTS	= $ 1,710	
	$ 40,730	DELTA COST
● ATL PAYLOAD		
• GSE CABLE COSTS		
741 CONDUCTORS X $40/CONDUCTOR	= $ 29,640	
46 CABLES X $200/CONNECTOR PAIR	= $ 9,600	
• INSTALLATION COSTS		
CABLE LENGTH X INSTALLATION TIME PER FOOT X MANPOWER		
(276 FEET) (0.25 HR/FT) (2 TECH) ($30/HR)	= $ 4,140	
• REMOVAL COSTS		
ONE HALF INSTALLATION COSTS	= $ 2,070	
	$ 45,450	DELTA COST

SUBSTITUTE INTER-RACK CABLES ARE NOT COST-EFFECTIVE

The installation and removal task for the GSE cabling was calculated on the basis that it would take 25% of the time that flight cabling would take. Although this analysis is related to whether or not flight floors were present, in the sense that GSE cabling would make more sense in a GSE substitute floor, flight cables would be used even with no floor present by positioning the racks in flight arrangement and carefully laying the flight cabling between them. This would allow early discovery of flight cable incompatibilities which would not be possible with the substitute approach.

The cost savings associated with inter-rack fluid lines for experiments is not as significant because there are significantly less lines and connectors involved. However, the same rationale for use of flight lines applies as was used for the cabling.

Freon Pump/Inverter - Substitution Analysis

In the baseline approach, the lead pallet in a pallet only or pallet/module payload comes equipped from KSC with a 400 Hz inverter and a Freon pump and accumulator package mounted on the front frame. Potential savings may accrue from not shipping the equipment to the Level IV site and deferring their installation until Level III. This allows the equipment to be used on other payloads and reduces the running time on the equipment, with attendant reliability benefits.

The following factors were considered in this analysis.

(a) Cost Savings - Based on the cost of the Freon pump package and inverter hardware, the prorated cost of utilization of this hardware is:

Freon Pump Package	\$44/Day
400 Hz Inverter	40/Day

Typically, deferring the installation of this hardware would save 35 days of involvement time, or approximately $3000 per flight.

(b) GSE Implications - A Freon Servicer and a Refrigeration Unit are required at the Level IV site to fill/bleed/circulate the Freon system and provide heat rejection during experiment operation, even if a Freon pump package is on the lead pallet, and serves the function of the package. There is therefore no need to use the package. Also, only the lead pallet has a pump package, so that trailing pallets in a multi-pallet payload would have to use the Servicer and Refrigeration Unit - unless interconnections were made and the checkout/servicing of the trailing pallets were made dependent on the integration status of the lead pallet.

With regard to the 400 Hz inverter, although 400 Hz power could be provided from the inverter to the lead pallet (and trailing pallets by interconnection, keeping in mind the limitations above) using 28 VDC power from the integration facility, a facility 400 Hz power supply is relatively

standard. Again, use of the facility power source would also save running time on the flight inverter.

(c) Distributed Site Implications - In either the minicenter or progressive situation, where the payload is dispersed geographically, the benefit of the presence of the 400 Hz inverter and the Freon pump package are only available to the lead pallet site.

(d) Logistics Considerations - If the use of these two Spacelab equipment items can be deferred until Level III assembly, pallet logistics may be simplified. The early description of lead pallet status and allocation could become complex as a result of inevitable schedule delays during the course of the program.

Remote Access Unit (RAU) - Substitution Analysis

The baseline scenario calls for Spacelab racks and pallets to arrive at the Level IV site equipped with the necessary number of RAU's required for the payload. These RAU's are then connected into the experiment hardware as it is installed, and used to functionally check the experiment data interfaces. The substitution approach would be to leave these RAU's off during Level IV, and installing a "substitute RAU" device electrically into the system. This reduces involvement time for the flight RAU's, with attendant savings, but necessitates removal of the substitute RAU's and replacement with flight RAU's at the Level III integration site. Checkout of the flight RAU interfaces would then be performed, with the risk in defective RAU's or interfaces then being assumed during on-line KSC activities.

Based on an estimated cost for the substitute RAU of $14,300 (one-tenth the cost of the $143,000 flight unit), the cost factors follow.

Savings

Reduced involvement time of RAU's - typically 35 days per flight

$143,000/2500 working days = $57.2/day
Savings in prorated cost - $57/day x 35 days/flight = $2002

Additional Costs

Cost of substitute RAU for 35 day period:

$6/day x 35 days/flight =	$210

Cost of installation/removal of substitute RAU:

(2 techs) x (4 hours) x ($30/hr.) =	240
(1 engr) x (4 hours) x (35/hr.) =	140

Retest requirements cost:

(2 engrs) x (10 hrs) x ($35/hr.) =	700
(1 tech) x (10 hrs) x ($30/hr) =	300
Total Additional Cost	$1590

Since the savings in prorated cost of flight equipment is very nearly offset by the additional cost, and since the substitution approach introduces potential risk associated with deferred interface checkout with the flight RAU's, this substitution approach does not appear to be viable.

Conclusions and Recommendations

As a result of the foregoing analyses, the following conclusions and recommendations are presented.

(a) SIPS Substitution - Substitution is indicated and recommended on the basis of the significant cost savings.

(b) IPS Substitution - Substitution is indicated and recommended, again on the basis of even greater cost savings to be realized.

(c) Module Floor Substitution - Substitution is not recommended, based on the additional cost, rather than savings, being realized.

(d) Rack Cabling Substitution - Substitution is not recommended, since the added cost of fabricating and installing GSE cabling appears to be excessive compared with the speculative savings in wear and tear on the flight cables.

(e) Freon Pump and Inverter Substitution - Substitution of GSE supplies of 400 Hz power and Freon coolant is recommended, based primarily on the reduction in operating time on these rather sensitive items of flight equipment. The cost factor favors this approach also, though not significantly.

(f) Remote Access Unit (RAU) Substitution - Substitution of RAU simulators for flight units is not recommended. The savings are insignificant in view of the potential risk incurred from deferring RAU installation and checkout of flight data interfaces.

DEDICATED SPACELAB EQUIPMENT UTILIZATION

The baseline approach presumes that experiments are disassembled from the Spacelab equipment after each flight and the Spacelab equipment is freed for integration with a subsequent payload. In contrast, the effects of dedicating selected pieces of Spacelab to specific experiments were explored and analyzed.

Certain savings in time and manpower will accrue from such an approach. Not only is the time and manpower needed to disassembly (or deintegrate) the experimental hardware after flight eliminated but also the time and manpower required to re-integrate the same equipment onto the Spacelab equipment for a subsequent mission. This savings then pyramids when one considers the reduction in involvement time of the GSE used, the reduced TDY expenses for integration personnel and the benefits of reducing the total processing time.

There are, of course, cost increases associated with dedication. Since the Spacelab hardware (i.e. a pallet) is "tied up" with the experiment hardware installed for periods of time between flights, there is a degree of underutilization of this hardware. The hardware is extremely expensive (over $3 million for a pallet) and the loss of utilization must be offset by the operating and other savings before dedication can be considered cost effective. This becomes a flight rate sensitive situation, because the degree of utilization of the Spacelab hardware depends on how often that payload is to be flown, up to the limit that the hardware will support considering the total ground processing time. It is noted that the total ground processing time is lower for a dedicated configuration than for one which must be totally integrated, such that it will support a higher flight rate than the baseline concept.

Assumptions and Methodology

Certain assumptions were made concerning the payload and its ground processing to render a consideration that dedicated Spacelab hardware is a viable option:

(1) Storage space for the payload hardware, in the integrated state, available at KSC at no added cost to the program.

(2) The experiment equipment of a type that does not have to be removed and returned to the Principal Investigator to extract data following the flight. It is assumed that the data is obtained from in-flight or ground recordings, telemetry, film etc. or from specimens removed from the experiment equipment and returned to the P.I.

(3) The experiment hardware is of such a design that it can readily be reflown for later missions of the same type with no significant modification required. It is anticipated that new specimens will have to be inserted in the equipment and perhaps minor adjustments performed, but major overhaul and modification activity is assumed to be unnecessary. The required specimen

insertion, minor refurbishment and adjustment is envirioned to be performed by a small cadre of P.I. personnel in the rack/pallet storage area or an adjacent laboratory at KSC, in an off-line period between flights.

(4) Refurbishment of the Spacelab racks and pallets dedicated to the experiment equipment will be minor in scope and can be performed offline (as is the experiment equipment refurbishment described above), and is not a delta cost chargeable to dedication. In addition, it is anticipated that the refurbishment required on this equipment between flights will be substantially less than required for a non-dedicated rack/pallet, since the wear and tear of integration and deintegration is avoided.

The methodology used to evaluate the option of dedicated Spacelab hardware was as follows.

Candidate Selection

The four payloads were reviewed, experiment end item by end item, to determine those which most probably would show operational and financial benefit from dedicating Spacelab hardware to the end item(s) in question. This screening consisted of completing a questionnaire for each experiment and end item. The questions considered were as follows.

(1) IS THE EQUIPMENT DESIGNED FOR MULTIPLE USE? That is, can the equipment be used for several similar experiments? This question refers to equipment such as the Space Processing Multipurpose Furnace, which is designed for flexibility, used with a variety of materials in melt experiments at various temperatures and time profiles. This characteristic indicates that reflight will be carried out and that extensive modification will not be required.

(2) IS THE EXPERIMENT ONE WHICH REQUIRES FREQUENT REFLIGHT TO GET MEANINGFUL DATA? This question identifies items which, by the nature of the experiment, depend on periodic flights for validity. An example would be the Microwave Radiometer of the ATL-A payload, used to measure ocean conditions of sea state, salinity, etc. One-time data is of very limited value; frequent flights for data would be needed for the experiment to be useful for weather forecasting, shipping or oceanography. Such an experiment complement would be a good candidate for dedication.

(3) IS THE EQUIPMENT OF A TYPE WHICH IS VERY DIFFICULT AND EXPENSIVE TO INSTALL AND/OR ADJUST AT LEVEL IV INTEGRATION? This is one of the key factors, heavily weighted in determining the prime candidates for dedication, since the economic feasibility of dedication depends largely on the savings in integration costs offsetting the cost of lower Spacelab equipment utilization. Equipment which is very costly and time-consuming to integrate onto the Spacelab equipment offers the greatest potential savings to accrue from dedication of the Spacelab equipment to that experiment equipment.

(4) DOES THE EQUIPMENT OCCUPY A MINIMAL AMOUNT OF SPACELAB EQUIPMENT, (I.E., ONE RACK RATHER THAN 5 RACKS)? The cost of dedication resulting from lower utilization of the Spacelab equipment depends in part on how much such equipment is "tied up". If the experiment end item ties up only one rack, for example, it would take only 1/5 as much savings to justify dedication as an item occupying 5 racks, thus making the former case a far better candidate for dedication.

(5) IS THE EQUIPMENT ESPECIALLY SENSITIVE TO WEAR-AND-TEAR DAMAGE FROM REPEATED INTEGRATION? Another consideration in analyzing the feasibility of dedication, though very difficult to handle quantitatively, is the potential for damage during the activity of removing the hardware from the racks/pallets, and then later reinstalling it. This would result in either degraded reliability or repair/scrappage. Since the equipment in question is only conceptually designed, a credible analysis of the degradation in reliability is not possible, but some idea of its vulnerability to such degradation is possible, and this has been attempted here. Equipment considered especially susceptible to such degradation is therefore considered a better candidate for dedication than those which are not so susceptible.

(6) IS THE EQUIPMENT ONE WHICH MUST BE FLOWN ON SHORT LEAD TIME SUCH THAT DELAY FROM THE INTEGRATION PROCESS IS UNDESIREABLE? Certain experiments, such as instruments to measure solar flare phenomena (not present in any of the study payloads), depend for their efficacy on the ability to be flown and positioned in space when the phenomenon is present and active. Since this is not predictable to any extent and may not last for a prolonged period, the experiment would have to be able to be put into a payload in very short notice and hence would have to be "standing by" in an already integrated (at Level IV) configuration. Dedication of its Spacelab equipment would be strongly indicated in such a case.

(7) IS THE EQUIPMENT SUCH THAT THE CONFIDENCE LEVEL OF SUCCESS WOULD BE SIGNIFICANTLY HIGHER IF LEVEL IV INTEGRATION WERE NOT PERFORMED REPEATEDLY? This question relates closely to item 5 above, regarding the potential for damage during integration. This item refers to more subtle effects which might occur, not evident as damage or detectable degradation. Like the effects referred to in item 5, the loss in reliability is not feasible to quantify and a "yes" answer is simply indicative of a better dedication candidate than a "no" answer.

(8) CAN THE EXPERIMENT OBJECTIVES BE MET IF THE EQUIPMENT IS LEFT INSTALLED IN THE SPACELAB HARDWARE? Some experiment equipment, such as the Space Processing Electromagnetic and Acoustic Levitation Melt facilities, are sealed units with test specimens installed, equipment inerted and calibrated before sealing. The units must be returned to the Principal Investigator for opening and removal of the specimens. Hence it is not feasible to dedicate any Spacelab equipment to such experiment equipment, regardless of any other factors. A "No" answer indicates a definite non-candidate for dedication.

A sample copy of this checklist form is enclosed as Figure 2-2. Another factor which was used to reject equipment items as candidates was uncovered during the analysis - cases where the experiment end item is not even integrated in Level IV Integration activities and therefore not mounted into Spacelab racks/palletc, etc. Equipment mounted in the Orbiter Aft Flight Deck is the best example of this, and such equipment evidently is not a viable candidate for dedication.

Following review of each experiment end item and completion of the referenced questionnaire, a "Dedication Candidate Rationale" sheet (Figure 2-3) was completed. This sheet recaps the "Yes" factors for each end item of the payload, and allows for recording and consideration of additional factors not covered in the questionnaire and usually unique to the payload end item or experiment being considered. The total factors favoring dedication are then considered and a decision made on whether or not all or part of the experiment should be considered a strong candidate for Spacelab hardware dedication. No specific weighting factors are applied to any of the factors, but a degree of subjective weighting was applied in accordance with the factor evaluation/descriptions above, with question 3 receiving the greatest weight.

Other less quantitative but equally tangible benefits accrue from dedication, some of which are mentioned in the questions above. They include:

(1) The ability to fly a payload on short notice.

(2) Less involvement time of the integration facilities, whether KSC, Lead Center or mini-center. This results from the shortened integration serial processing time and may or may not have real monetary value depending on facility utilization.

PAYLOAD ATL-A	EXPERIMENT ST-3 Tunable Laser for Atmospheric Constituents									
	END ITEM									
	I	II								
Is the equipment designed for multiple use, i e., usable for several similar experiments?	No	No								
Is the experiment one which by its nature, requires frequent reflight to get meaningful data?	Yes	Yes								
Is the equipment of a type which is very difficult and expensive to install/adjust at Level IV?	No	No								
Does the equipment occupy a minimal amount of Spacelab equipment (i e , one rack rather than 5 racks)?	Yes	Yes								
Is the equipment especially sensitive to wear-and-tear damage from repeated integration?	No	No								
Is the experiment one which must be flown on short lead time such that delay of integration process is undesirable?	No	No								
Is the equipment such that the confidence level of success would be significantly higher if Level IV integration were not performed repeatedly?	No	No								
* Can experiment objectives be met if equipment is left installed on Spacelab?	Yes	Yes								
* "No" indicates a definite non-candidate										
TOTAL "YES" FACTORS	3	3								

Figure 2-2. Equipment Dedication Checklist - Sample Form

DEDICATION CANDIDATE RATIONALE

PAYLOAD ATL-A

EXPERIMENT ST-3 Tunable Laser for Atmospheric Constituents

CHECKLIST FINDINGS

END ITEM NUMBER/NAME	TOTAL YES FACTORS
#I - 14 except II - Laser module	3
#II - Scan/Track Controller & C/D Panel	3

OTHER FACTORS AND RATIONALE

Due to checklist findings, especially non-multiuse nature of equipment and ease of integration into both Pallet 2 and Rack 4A, dedication of rack or pallet is not indicated

CONCLUSION

Not a candidate for dedication

Figure 2-3. Dedication Candidate Rationale - Sample Form

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(3) Less risk of damage, misalignment, misadjustment, etc. resulting from repeated removal and reinstallation.

(4) Less expense in refabrication of cables, harnesses and tubing runs which are damaged in removal and cannot be reused for the next integration.

(5) Special skills required for integration may be dispensed with on reflights to some degree. For example, if a certified brazing technician were required to install some tubing assemblies during integration, and the tubing were not removed after flight from the pallet because the pallet was dedicated to that experiment, re-integration of the experiment would not require the brazing specialist (unless repairs or modifications were needed).

(6) The expense of shipping experiment equipment from KSC to the P.I. site, as well as the special packaging required, would be saved. Likewise, the packing and shipping back to the integration site for the next flight would be saved.

Dedication Candidates

After exercising the selection rationale and procedure discussed above, the following candidates for dedication were selected.

Space Processing:

Pallet 1 dedicated to Facilities 3 and 4. Rationale: High cost of integrating and multiuse capability of these facilities. Facilities 1 and 2 must be removed to obtain test data.

Combined Astronomy:

Pallet 1 - dedicated to experiments AS-05 and UV-2. Rationale: High integration cost of SIPS assembly and harnessing onto pallet, and several lesser factors favoring integration.

Pallet 3/4 - dedicated to AS-01-S (SIRTF). Rationale: High cost and complexity of integrating harnesses, tubing, etc. onto pallets, and several lesser factors favoring integration. The IPS (on Pallet 2) is assumed to be installed and aligned offsite (in staging).

Advanced Technology Laboratory:

Pallet 1 - dedicated to experiment ST-10. Rationale: Experiment is very complex and expensive to integrate onto pallet, and nature of experiment indicates high reflight potential. ST-25 cryo dewars are to be removed.

Racks 5, 6 and Floor Assembly - dedicated to ST-25 (Combustion Facility). Rationale: The cost of integration is very high due to alignment of racks and combustion chamber on floor, multiple cable and line runs etc. Also, facility is designed for multi-specimen use in zero-G combustion testing, enhancing reflight probability. These two racks and floor segment form a complete experiment unit which should remain integrated if frequent reflight is planned.

. Life Sciences:

Racks 11, 12 and Floor Assembly - dedicated to experiment X-76. Rationale: As with the rack/floor assembly in ATL-A, this assembly involves very costly and complex integration installations and cost; by far the greatest of any experiment in this payload. Its reflight probability is also good, and other factors favor its candidacy. The subject racks and floor are totally occupied by this experiment, making it a complete experiment unit.

Dedication Cost Analysis - Ground Processing

In order to determine the effect of dedication on the detailed Installation and Test Sequence in Level IV integration, the baseline I&T "waterfall" charts were reviewed. In this review, those steps which would not have to be reperformed if the dedication were in effect, were identified. Only installation steps were so identified; it was assumed that a full sequence of experiment and payload level testing would still be performed. Some steps were eliminated and others shortened or modified in this review. The manpower associated with the modified or deleted steps was tallied, and the effect on total processing time calculated. The I&T charts were then revised to describe what would occur on re-integration in the case of a dedicated set of Spacelab equipment for each candidate case listed in the above section, "Dedication Candidates".

It should be noted that only the lead center I&T charts were used for this review, and the resultant savings in manpower applied to all processing options. This approach is believed to be acceptable in that the specific steps deleted or modified as a result of dedication would be the same whether the work was done at a mini-center, a lead center or at KSC, and whether it was followed by Blocks 7, 8 and 9 (Combined Checkout) or not.

Manpower Savings From Dedication

To obtain the manpower savings attendant to dedication for the <u>de-integration</u> sequence, the "Waterfall" charts for that sequence were also reviewed in the same manner as the Installation and Test charts, and revised sequence charts constructed.

Figures 2-4 through 2-9 represent the revised Lead Center Installation and Test "waterfalls" considering each of the dedication candidates. Figures 2-10 through 2-15 represent the deintegration waterfall charts revised in the same manner. The manpower and time savings extracted from this data was then subtracted from the baseline manpower

estimates to determine the manpower and TDY costs for the dedicated approach. These data are given in Table 2-11 through 2-16, along with figures for the other cost factors discussed below.

Dedication Cost Analysis - GSE Utilization

To determine the effect of Spacelab hardware dedication on the cost of GSE, GSE Utilization/Involvement Time charts were prepared as they were for baseline cost estimation. For the dedicated case, however, the effects of dedication were introduced. These effects were basically (1) shortening of the total serial processing time in Level IV Integration (Blocks 3 through 9) and Deintegration (Block 16), with resultant shortening of involvement time, (2) deletion of some GSE items from use altogether and (3) possible changes in transportation requirements and costs. The total GSE prorated costs were then calculated based on unit cost and involvement time, as they were for the baseline costs. Transportation also was refigured by the baseline procedure, where changes were found.

Tables 2-6 through 2-10 present these data for the six dedication candidates, where they vary from the baseline GSE data. The resultant cost figures are also shown in the Dedicated Cost Analysis tables for each candidate.

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

RECEIVE SPACELAB FLIGHT EQUIPMENT WITH SUBSYSTEMS INSTALLED; EXPERIMENT FLIGHT EQUIPMENT; CONSOLES; AND SPACELAB/EXPERIMENT/CONSOLE-UNIQUE & COMMON GSE
TRANSPORT ALL EQUIPMENT TO LEVEL IV WORK AREA OR TO STORAGE AREA (5)
PERFORM RECEIVING INSPECTION ON ALL EQUIPMENT EXCEPT THE SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF) AND THE MEDIUM ENERGY GAMMA RAY DETECTOR (MEGRD) (8)
INSTALL SIRTF PANEL "A" ON THE PSS PANEL RACK (8)
INSTALL SIRTF PANEL "B" ON THE PSS PANEL RACK (6)
INSTALL UV PHOTOMETER/TELESCOPE (UV/PT) PANEL IN THE PSS PANEL RACK (7)
INSTALL SMALL INSTRUMENT POINTING SYSTEM (SIPS) PANEL IN THE PSS PANEL RACK (5)
INSTALL FAR UV SCHMIDT CAMERAS/TELESCOPE PANEL IN PSS PANEL RACK (5)
INSTALL INSTRUMENT POINTING SYSTEM (IPS) PANEL IN PSS PANEL RACK (4)
INSTALL MEGRD PANEL IN PSS PANEL RACK (5)
CONNECT PSS PANELS TO CB57 AT PORT LEADING EDGE OF PALLET #1 (DIRECT SIGNAL CABLES) & TO OPERATORS CONSOLE (S/S & EXPERIMENT I/L UNITS) (4)
CONNECT OPERATORS CONSOLE TO CB51 AT STARBOARD LEADING EDGE OF PALLET #1 (4)
CONNECT GSE FLEX FREON LINES TO THE S/S FREON LOOP BETWEEN PALLETS #1 & #2 (5)
CONNECT GSE SIGNAL CABLES BETWEEN PALLETS #1 & #2 (5)
CONNECT FREON SERVICER (#612084A) TO REFRIGERATION UNIT (#612115A) & TO S/S FREON LOOP Q/D's AT THE I/F CONNECTOR BRACKET ON PORT LEADING EDGE OF PALLET #1. CONNECT REFER. UNIT TO FACILITY H_2O. SERVICE S/S FREON SYSTEM (10)
CONNECT GSE FLEX FREON LINES TO THE S/S FREON LOOP BETWEEN PALLETS #4 & #5 (5)
CONNECT GSE FLEX FREON LINES TO THE S/S FREON LOOP BETWEEN PALLETS #2 & #3 (5)
CONNECT GSE SIGNAL CABLES BETWEEN PALLETS #4 & #5 (5)
CONNECT GSE SIGNAL CABLES BETWEEN PALLETS #2 & #3 (5)
CONNECT GROUND POWER CABLE TO PERIPHERAL EQUIPMENT CONSOLE; TO OPERATORS CONSOLE; TO PSS PANELS; & TO GROUND POWER SOURCE, COMMAND SPACELAB SUBSYSTEMS "ON" AT THE PERIPHERAL EQUIPMENT CONSOLE (2)

FOLDOUT FRAME 1

PALLET #1

LOCATE PALLET #1 IN ITS PALLET INTEGRATION POSITION

PALLET #2

LOCATE PALLET #2 IN ITS PALLET INTEGRATION POSITION
INSTALL HARNESS CONTAINING SC-6A, SC-7A & SC-8A BETWEEN CB53, PALLET #2, & THE IPS BASE CONNECTOR BRACKET (CB) (4)
INSTALL HARNESS CONTAINING PC-3A, & PC-4A BETWEEN EPDB, PALLET #2 AND THE IPS BASE CB (5)

PALLET #3/4

PERFORM RECEIVING INSPECTION OF SIRTF EQUIPMENT - VERIFY TELESCOPE IS EVACUATED (15)
LOCATE PALLETS #3/4 IN THEIR PALLET INTEGRATION POSITION
INSTALL HARNESS CONTAINING SC-3, SC-4, SC-3B, PC-3B, & PC-4B BETWEEN THE MIC & THE IPS/SIRTF I/F RING CB - (STOW MIC END FOR LATER CONNECTION) (6)
INSTALL HARNESS CONTAINING SC-7B & PC-6 BETWEEN THE CRYOGEN TANK HEATER & THE IPS/SIRTF I/F RING CB - (STOW HEATER END FOR LATER CONNECTION) (8)
INSTALL HARNESS CONTAINING SC-6B & PC-8 BETWEEN THE SUNSHADE ACTUATOR & THE IPS/SIRTF I/F RING CB - (STOW SUNSHADE END FOR LATER CONNECTION) (19)
INSTALL HARNESS CONTAINING SC-5 (9 HRS) & SC-10 (REMAINING 13 HRS) BETWEEN CB53, PALLET #3 & THE SIRTF ATTACH TRUNNIONS POWER/SIGNAL DISTRIBUTION BOX (SC-5) AND THE SIRTF COVER ACTUATORS (SC-10) - (STOW DISTRIBUTION BOX & COVER ENDS FOR LATER CONNECTION) (22)
INSTALL HARNESS CONTAINING SC-9 & PC-5 BETWEEN THE SIRTF ATTACH TRUNNIONS POWER/SIGNAL DISTRIBUTION BOX & THE EXPERIMENT RAU, PALLET #4 (SC-9), AND THE EPDB, PALLET #4 (PC-5) - (STOW DISTRIBUTION BOX END FOR LATER CONNECTION) (10)
INSTALL PC-7 BETWEEN EPDB, PALLET #4, AND THE SIRTF COVER ACTUATORS - (STOW COVER END FOR LATER CONNECTION) (13)
HOIST SIRTF TO PALLETS #3/4 & LOCATE IN POSITION (6)
PERFORM ALIGNMENT OF SIRTF & TORQUE ATTACH BOLTS TO PALLETS #3/4 PER INSTALLATION DRAWING (8)
CONNECT GROUND POWER CABLE TO SIRTF EXTERNAL POWER RECEPTACLE (FOR VACUUM PUMP) (1)
CONNECT ALL CONNECTORS LEFT STOWED PRIOR TO SIRTF INSTALLATION (5)

PALLET #5

PERFORM RECEIVING INSPECTION OF MEGRD EQUIPMENT (16)
LOCATE PALLET #5 IN ITS PALLET INTEGRATION POSITION
INSTALL HARNESS CONTAINING SC-11 & PC-9 BETWEEN EXPERIMENT RAU, PALLET #5 (SC-11), & EPDB, PALLET #5 (PC-9), & THE MEGRD - (STOW MEGRD ENDS FOR LATER CONNECTIONS (5)
HOIST MEGRD TO PALLET #5 & LOCATE IN POSITION (6)
PERFORM ALIGNMENT OF MEGRD & TORQUE ATTACH BOLTS TO PALLET #5 PER INSTALLATION DRAWING (4
CONNECT SC-11 & PC-9 CONNECTORS TO THE MEGRD (2)

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VERIFY LEVEL IV INSTALLATIONS OF THE UV/PT & FAR UV SCHMIDT CAMERAS/TELESCOPE EXPERIMENTS USING PSS PANEL RACK (8)

a SIPS MAIN POWER CONTROL FUNCTION ON-OFF
b. CANISTER LAUNCH/ENTRY LATCH OPERATION
c. SIPS OPERATION ABOUT Z AXIS
d. SIPS OPERATION ABOUT Y AXIS
e. CANISTERS ABOUT YOKE Z AXIS
f JETTISON CIRCUIT INTEGRITY
g CANISTER "A" PURGE PRESSURE
h. SIPS SCHMIDT CAMERA DOOR OPEN/CLOSE FUNCTION
i. SCHMIDT SYSTEM MAIN POWER ON/OFF FUNCTION
j. SCHMIDT SYSTEM CAMERA 1 & 2 ON/OFF FUNCTION
k. SCHMIDT SYSTEM TV CAMERAS OPERATING FUNCTION
l. SCHMIDT SYSTEM FILM ADVANCE OPERATION
m. SCHMIDT SYSTEM DATA RETURN
n. CANISTER "B" PURGE PRESSURE
o. PHOTOMETER MAIN POWER ON/OFF CONTROL FUNCTION
p. CHANNELTRONS (C1 TO C7) & PHOTOMETER (PM-1 TO PM-4) LOW VOLTAGE ON/OFF
q. CHANNELTRONS (CT-1 TO CT-7) & PHOTOMETERS (PM-1 TO PM-4) LOW VOLTAGE ON/OFF
r. PHOTOMETER MODE CONTROL LOCAL/REMOTE
s. PHOTOMETER CALIBRATION SOURCE CT & PM IN/OUT
t. PHOTOMETER COMMAND ENABLE/EXECUTE
u. PHOTOMETER STAR PRESENCE RELATIVE MAGNITUDE METER
v. PHOTOMETER TRACKER LOCK ON/OFF
w. PHOTOMETER DETECTOR MALFUNCTION POWER ON/OFF
x. PHOTOMETER DETECTOR MALFUNCTION AUDIO SELF/TOT
y. PHOTOMETER OPERATION CONTROL FUNCTION

VERIFY LEVEL IV INSTALLATIONS OF THE SIRTF EXPERIMENT USING THE PSS PANELS (18)

a. SIRTF PANELS A&B MAIN POWER CONTROL
b. IPS MAIN POWER CONTROL
c. POWER VOLTAGE AT SIRTF
d. TEST COMMAND PROGRAMMED SEQUENCE RECEIVED AT SIRTF
e. TELESCOPE COVER ENGAGE/DISENGAGE LATCHES (SIMULATED)
f TELESCOPE COVER EXTEND/RETRACT (SIMULATED)
g. TELESCOPE TRUNNION ENGAGE/DISENGAGE (4 PLACES) (SIMULATED)
h. IPS RING - TELESCOPE COUPLING (SIMULATED)
i CRYOGENIC TANK PRESSURE READOUT
j. CRYOGENIC TANK PRESSURE QUANTITY READOUT
k. SUNSHADE EXTEND/RETRACT (SIMULATED)
l. SECOND MIRROR POSITION 1/POSITION 2
m. SIRTF INTERNAL CALIBRATION
n. VIDEO INSTRUMENT POINTING SYSTEM CONTROL FUNCTION
o SUN AVOID ON/OFF FUNCTION
p. SIRTF MODE SWITCH AUTO/MANUAL FUNCTION
q. CRYO FLOW RATE CONTROL FUNCTION
r. CRYO PURGE ON/OFF FUNCTION (SIMULATED)
s. WATER DUMP CONTROL FUNCTION (SIMULATED)
t. IPS X, Y & Z CONTROL & RESPONSE (4)

VERIFY LEVEL IV INSTALLATIONS OF THE MEGRD EXPERIMENT USING THE PSS PANEL RACK (3)

a. COMMAND & DISPLAY PANEL POWER CONTROL FUNCTION
b. POWER TO EXPERIMENT ON/OFF CONTROL FUNCTION
c. HIGH VOLTAGE UPPER & LOWER SPARK CHAMBER CONTROL FUNCTION & POWER VOLTAGE AT EXPERIMENT
d. TIME OF FLIGHT FUNCTION
e. SPARK CHAMBER GAS PRESSURE CONTROL & DISPLAY FUNCTION
f. CRT & KEYBOARD FUNCTION & DISPLAY FOR ITEMS a THROUGH e

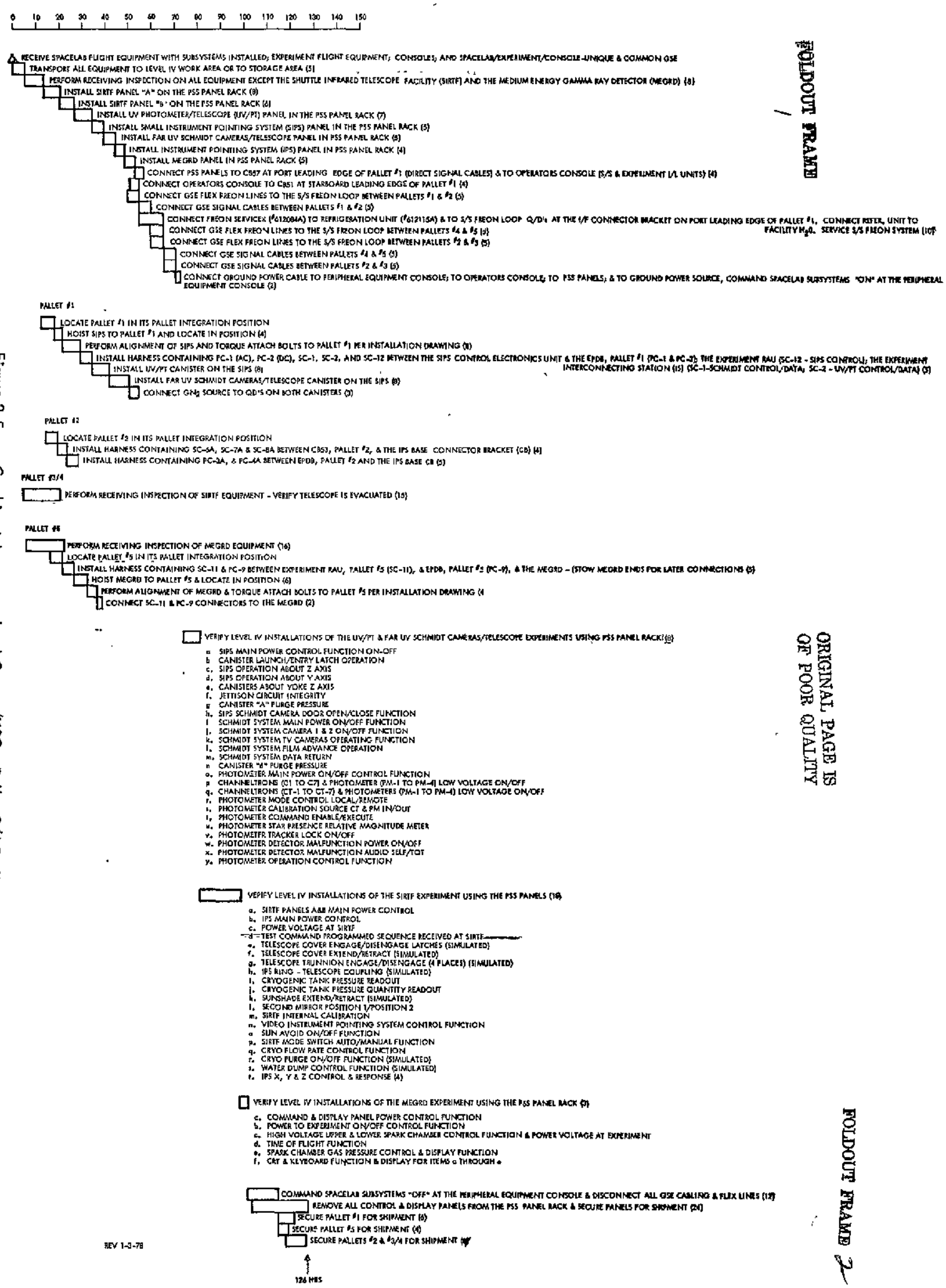
FOLDOUT FRAME 2

COMMAND SPACELAB SUBSYSTEMS "OFF" AT THE PERIPHERAL EQUIPMENT CONSOLE & DISCONNECT ALL GSE CABLING & FLEX LINES (12)
REMOVE ALL CONTROL & DISPLAY PANELS FROM THE PSS PANEL RACK & SECURE PANELS FOR SHIPMENT (24)
SECURE PALLET #1 FOR SHIPMENT (6)
SECURE PALLET #5 FOR SHIPMENT (4)
SECURE PALLETS #2 & #3/4 FOR SHIPMENT (8)

126 HRS

REV 1-3-78

Figure 2-4. Combined Astronomy Lead Center/KSC - Pallet 1 Dedicated



REV 1-3-78

Figure 2-5. Combined Astronomy Lead Center/KSC - Pallet 3/4 Dedicated

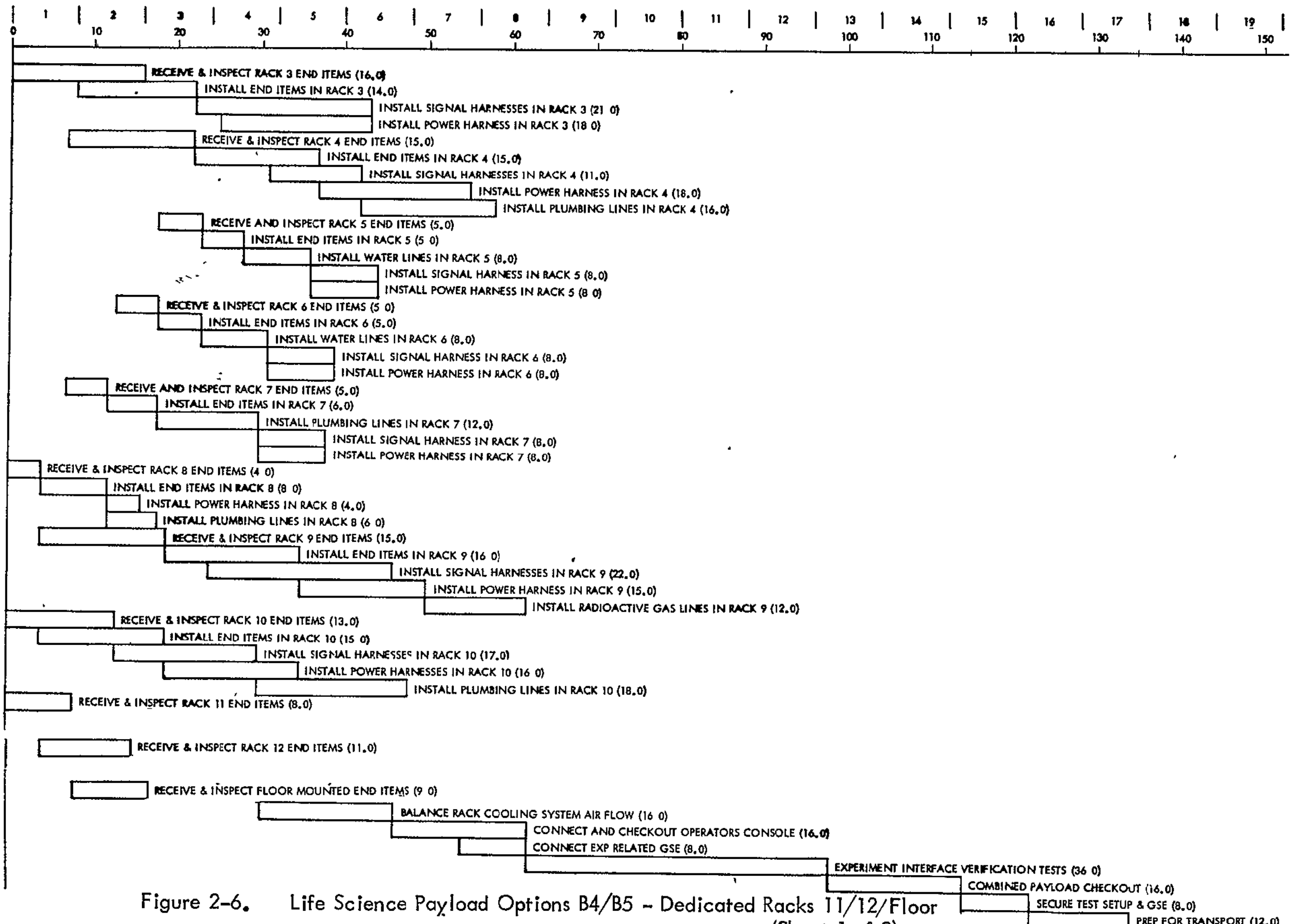


Figure 2-6. Life Science Payload Options B4/B5 - Dedicated Racks 11/12/Floor (Sheet 1 of 2)

SD 78-SR-0009-3

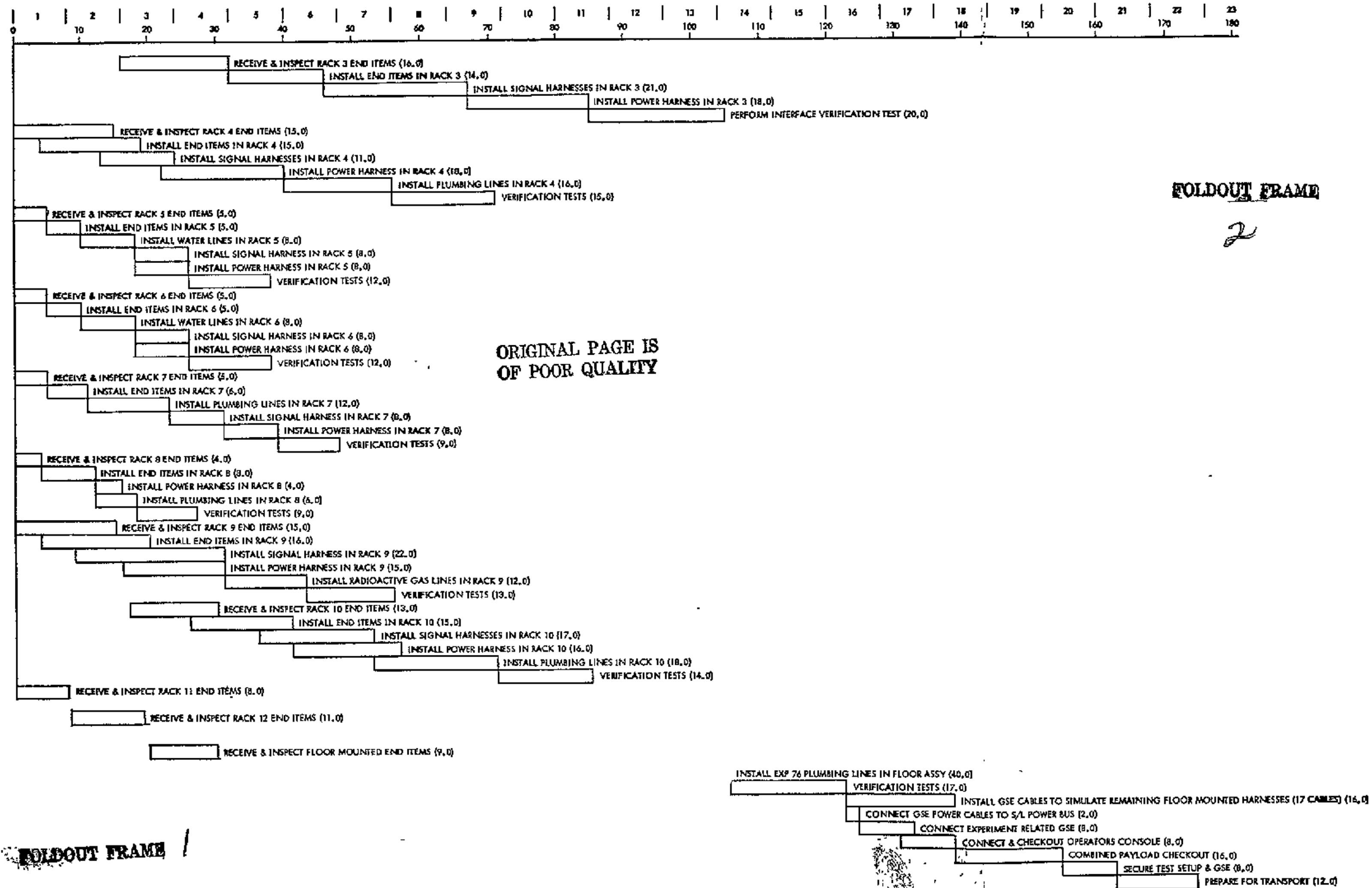


Figure 2-6. Life Science Payload Options B1/B2 Dedicated Racks 11/12/Floor (Sheet 2 of 2)

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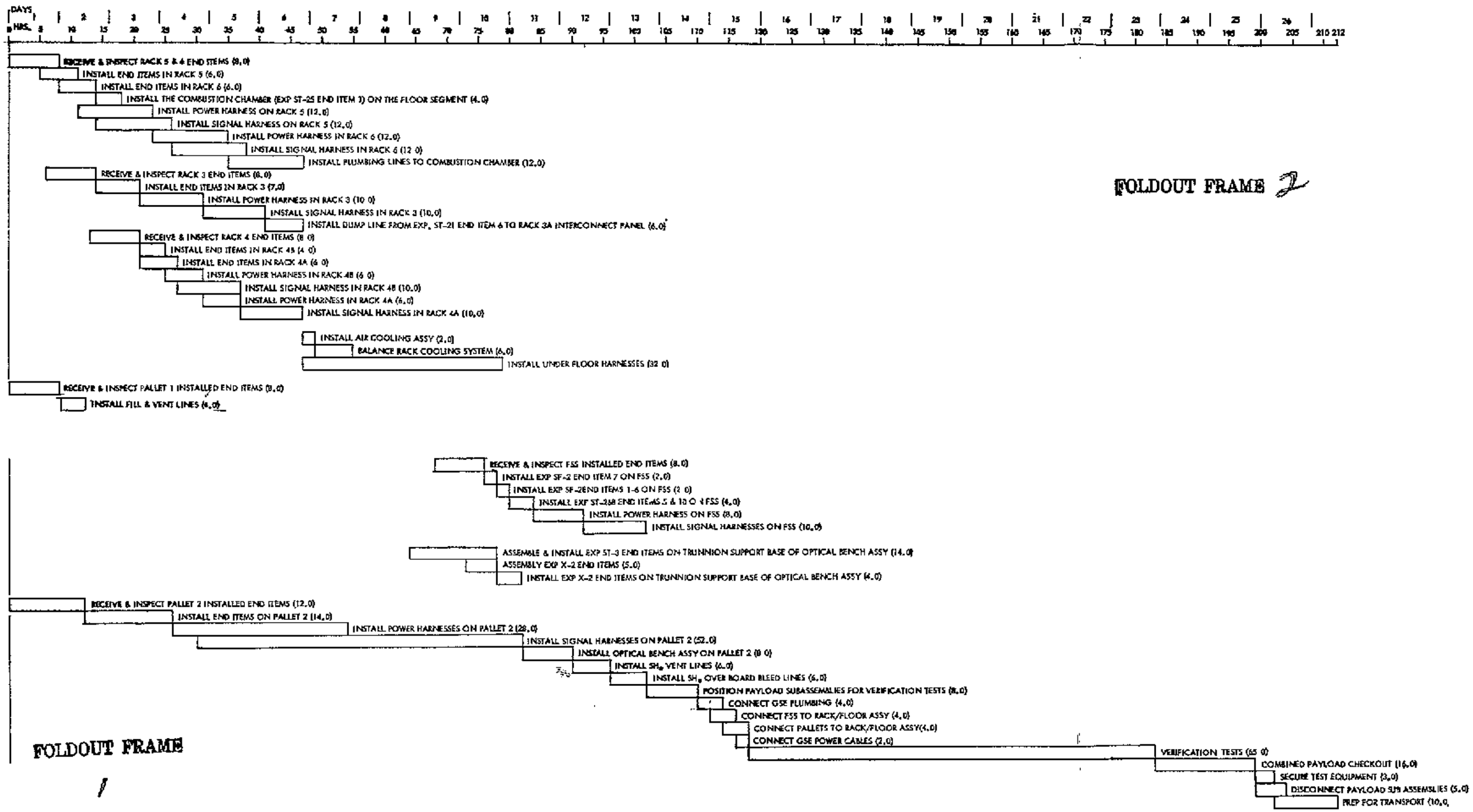

FOLDOUT FRAME 2

FOLDOUT FRAME 1

Figure 2-7. ATL Payload - Options B4/C4 Dedicated Pallet 1 (Sheet 1 of 2)

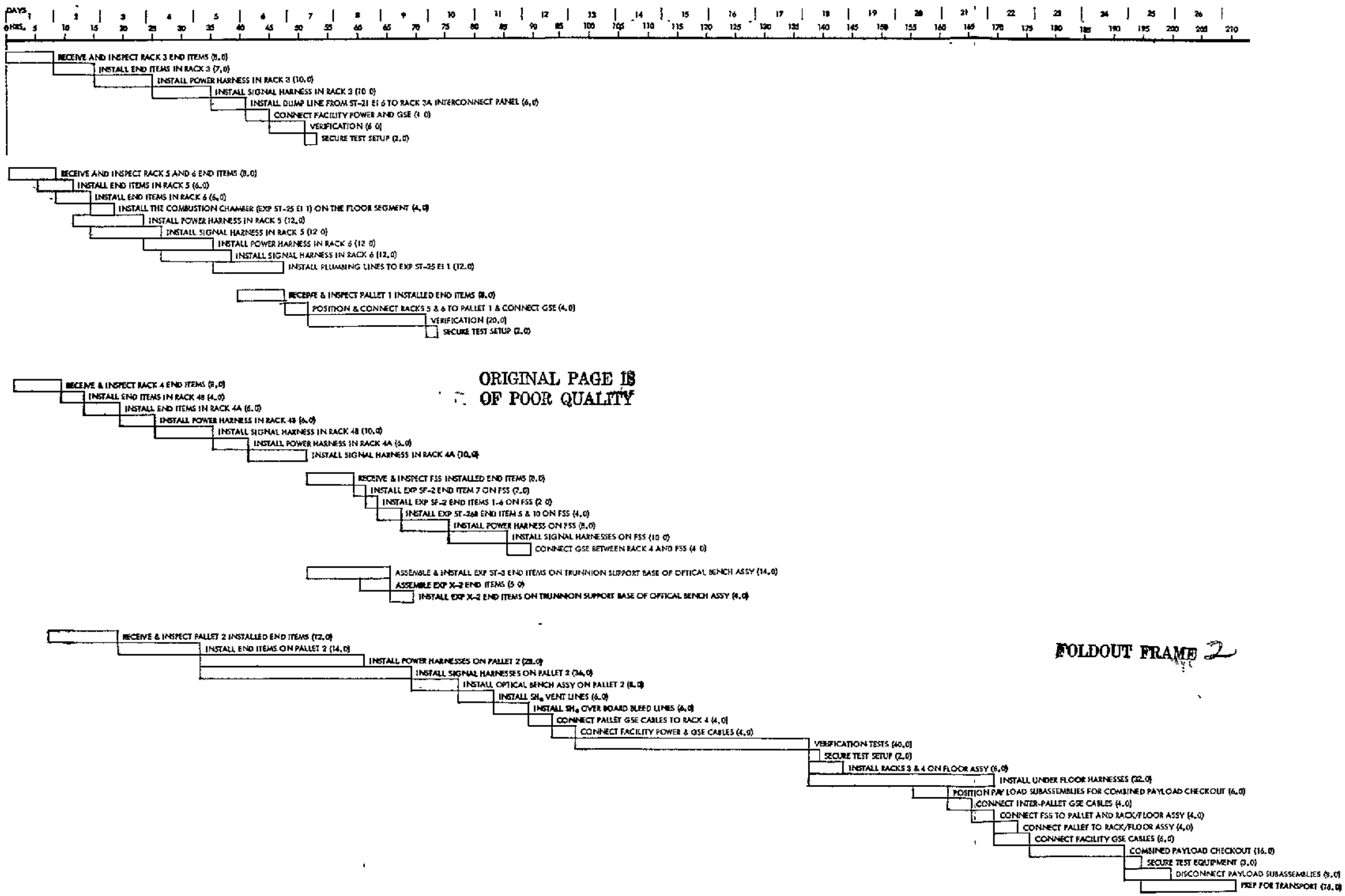

Figure 2-7. ATL Payload - Options B1/C1/C3 Dedicated Pallet 1 (Sheet 2 of 2)

FOLDOUT FRAME 1

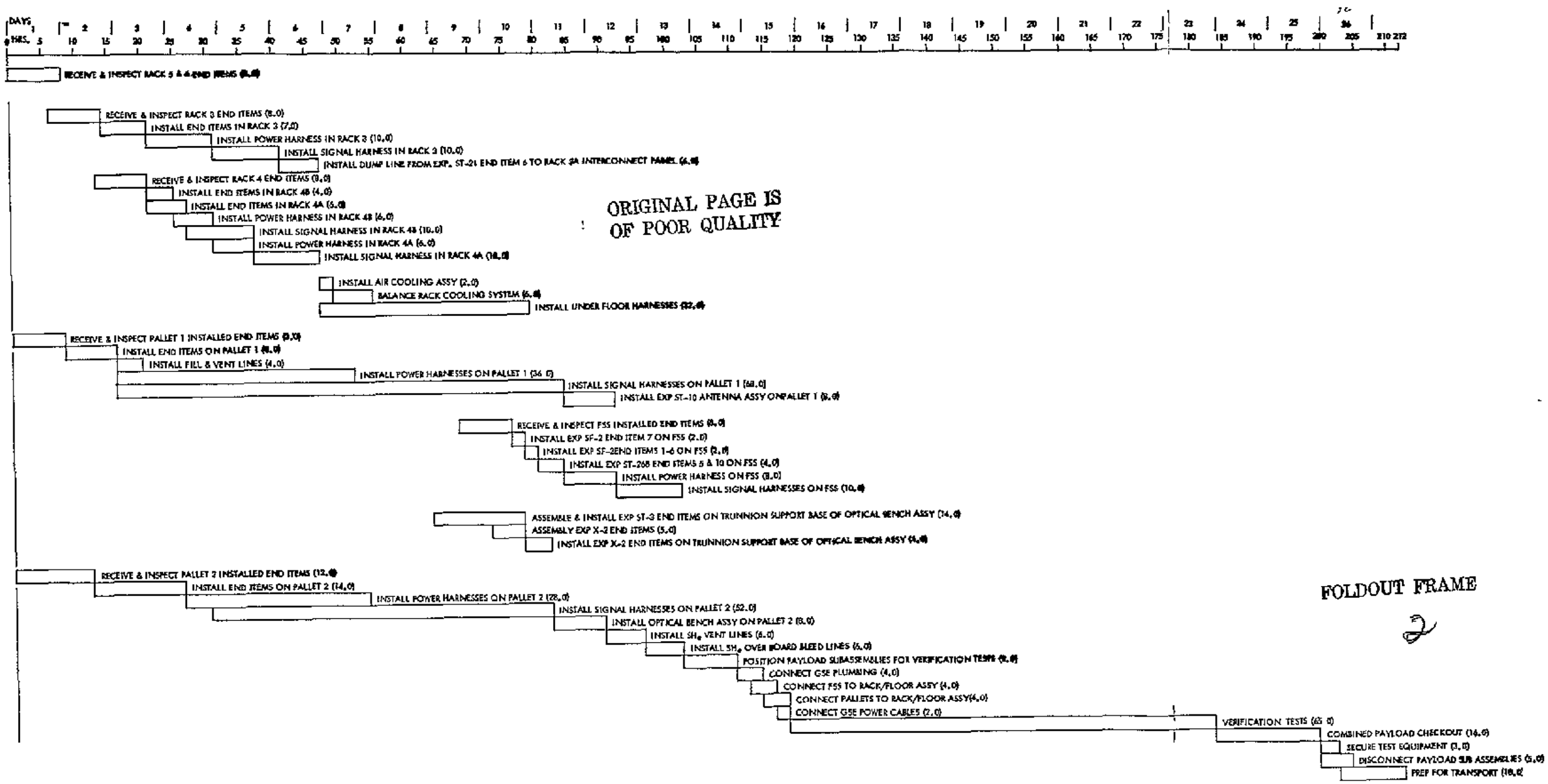

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Figure 2-8. ATL Payload Options B4/C4 - Dedicated Racks 5/6/Floor (Sheet 1 of 2)

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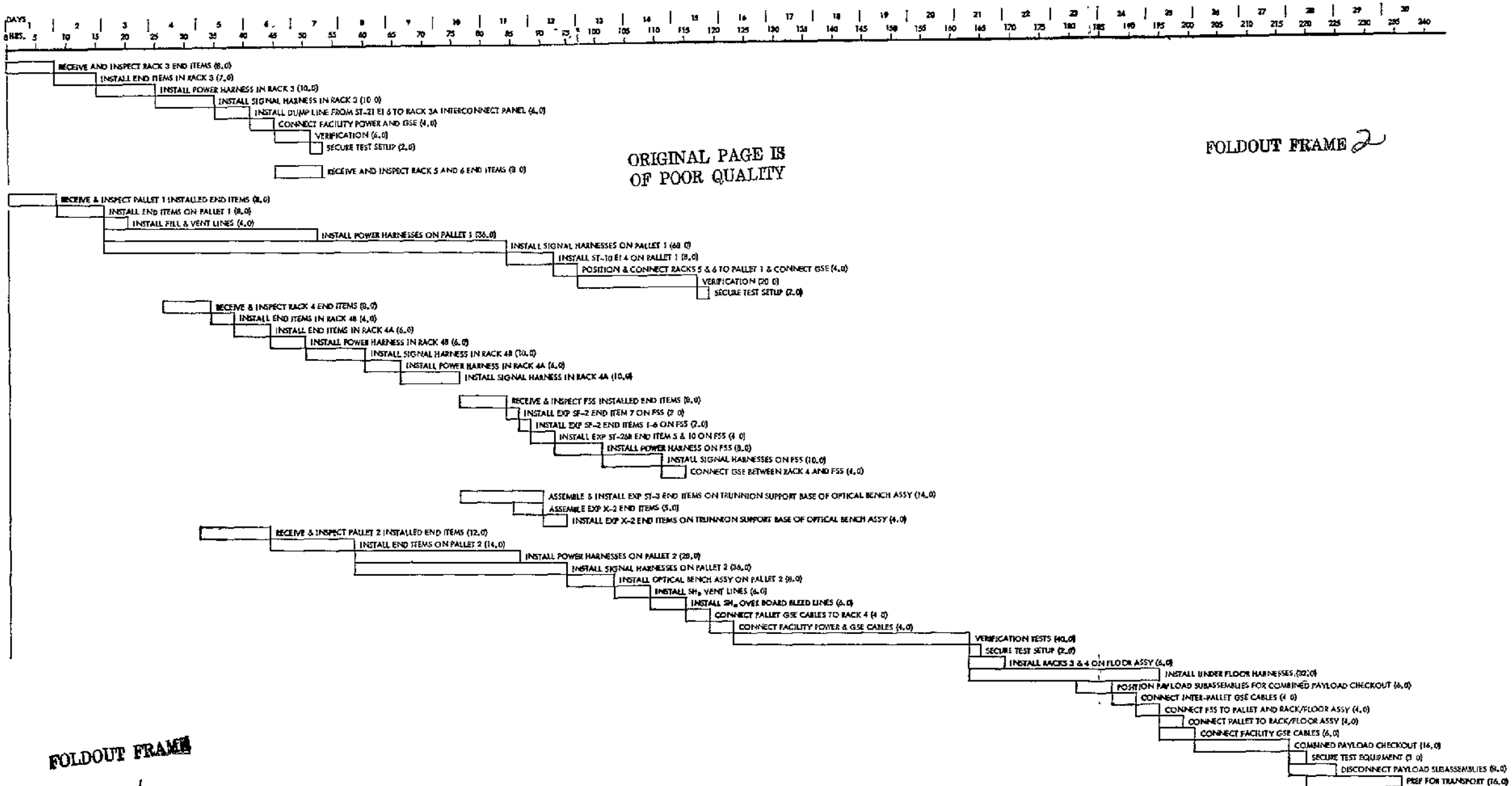

FOLDOUT FRAME 1

Figure 2-8. ATL Payload Options B1/B3/C1/C3 - Dedicated Racks 5/6/Floor (Sheet 2 of 2)

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FOLDOUT FRAME 2

FOLDOUT FRAME 1

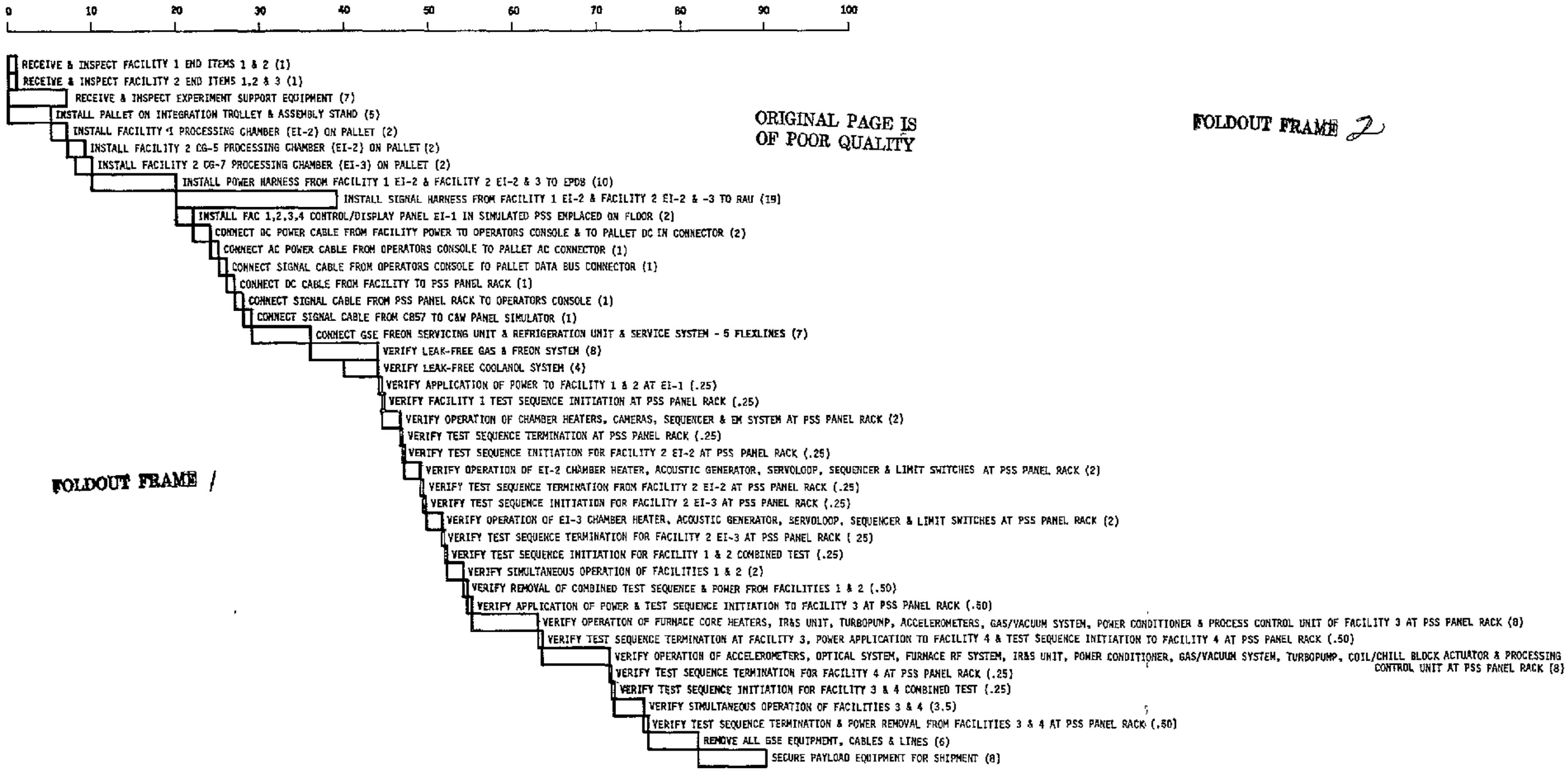

Figure 2-9. Space Processing Payload - Lead Center/KSC Flow - Dedicated Pallet

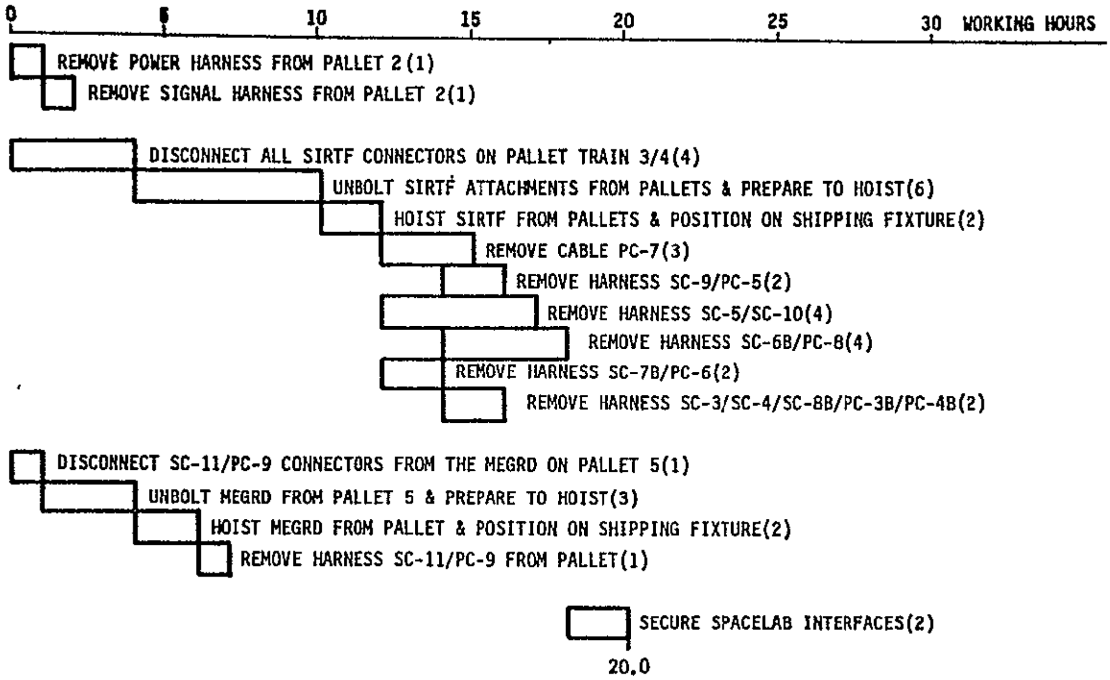

Figure 2-10. Level IV Deintegration - Combined Astronomy - Pallet 1 Dedicated

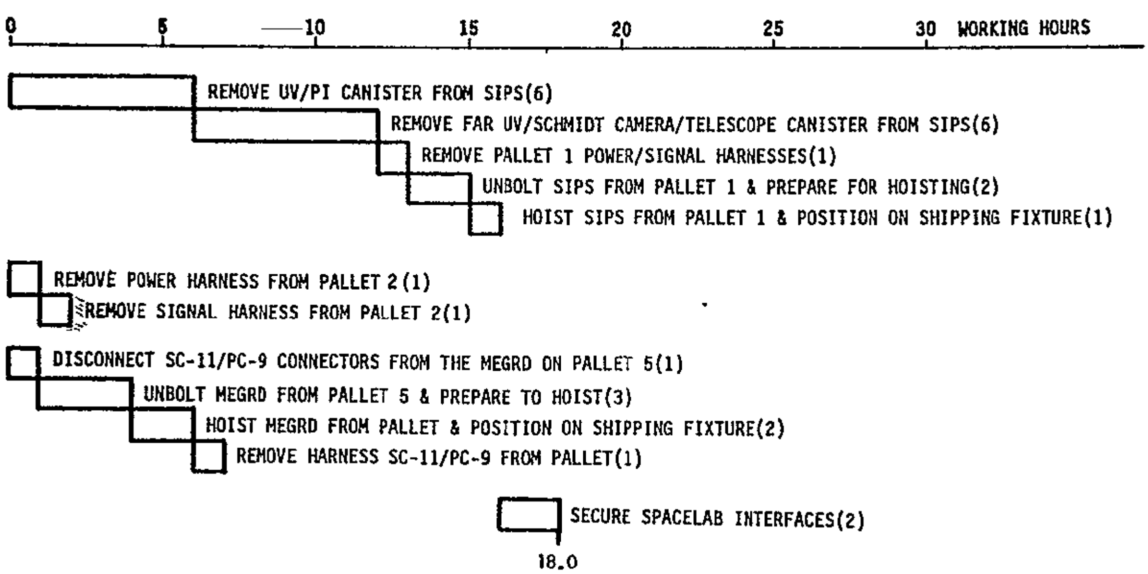

Figure 2-11. Level IV Deintegration - Combined Astronomy - Pallet 3/4 Dedicated

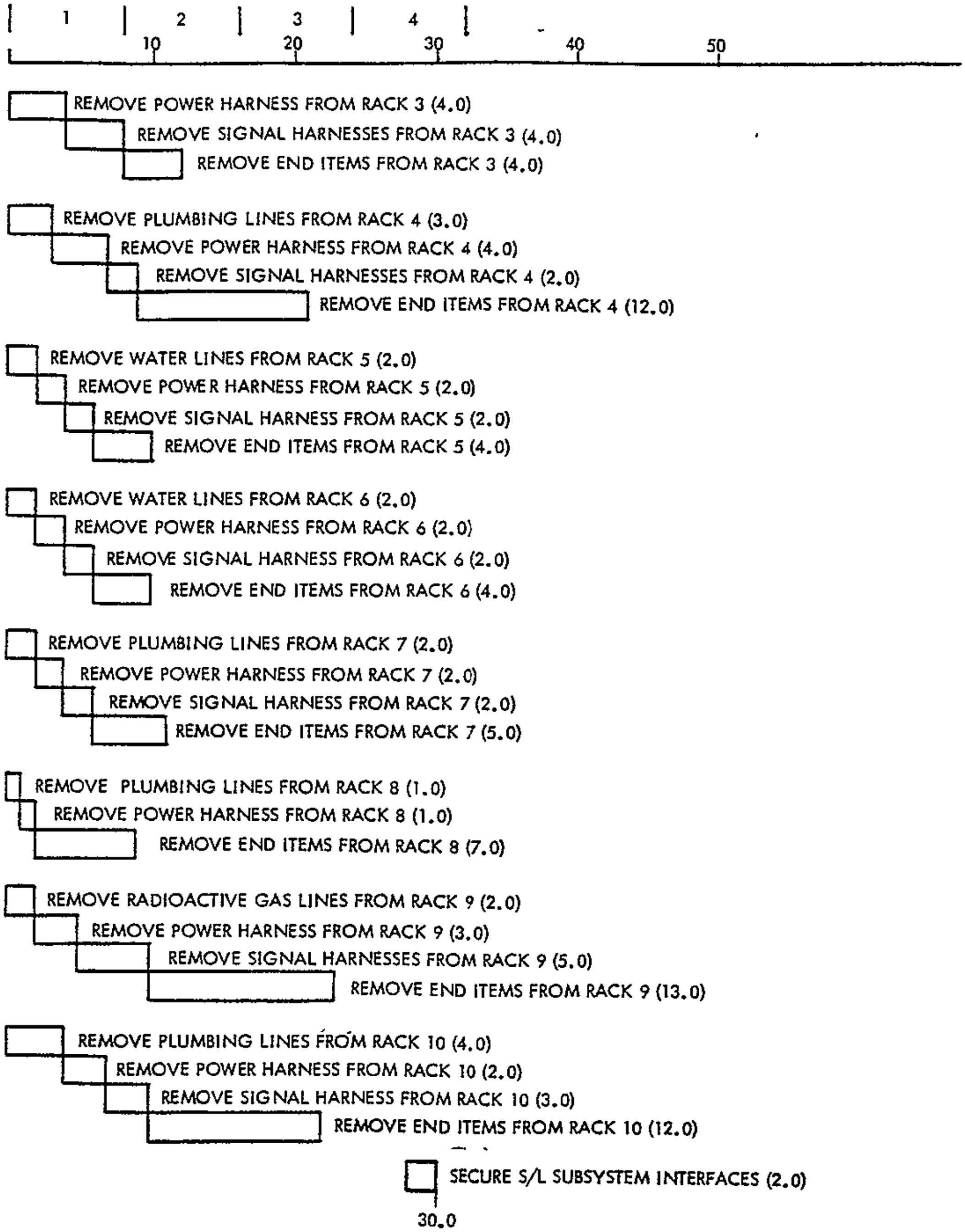

Figure 2-12. Level IV Deintegration - Life Science Rack 11/12/Floor Dedicated

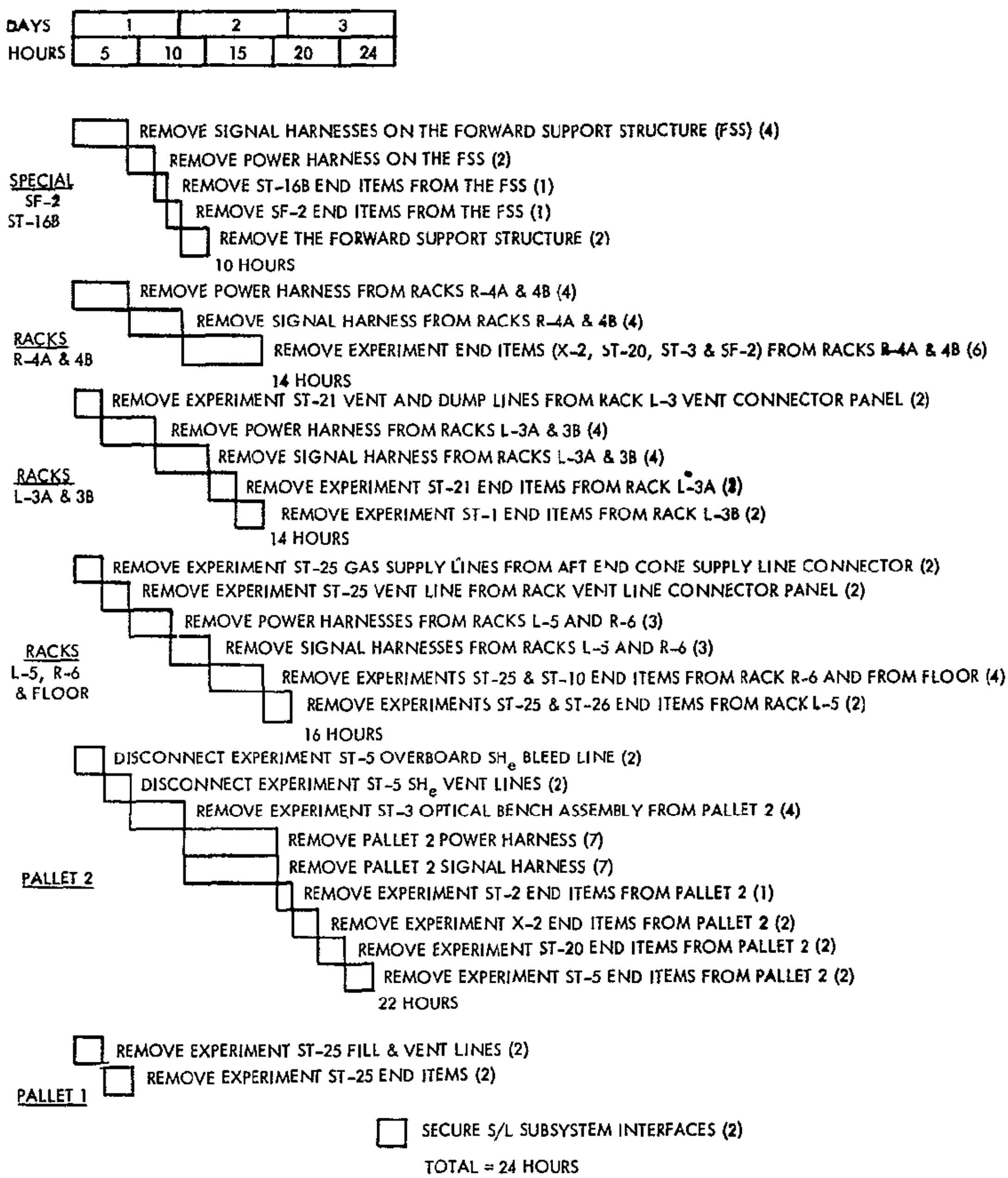

Figure 2-13. ATL Payload Level IV Deintegration Pallet 1 Dedicated

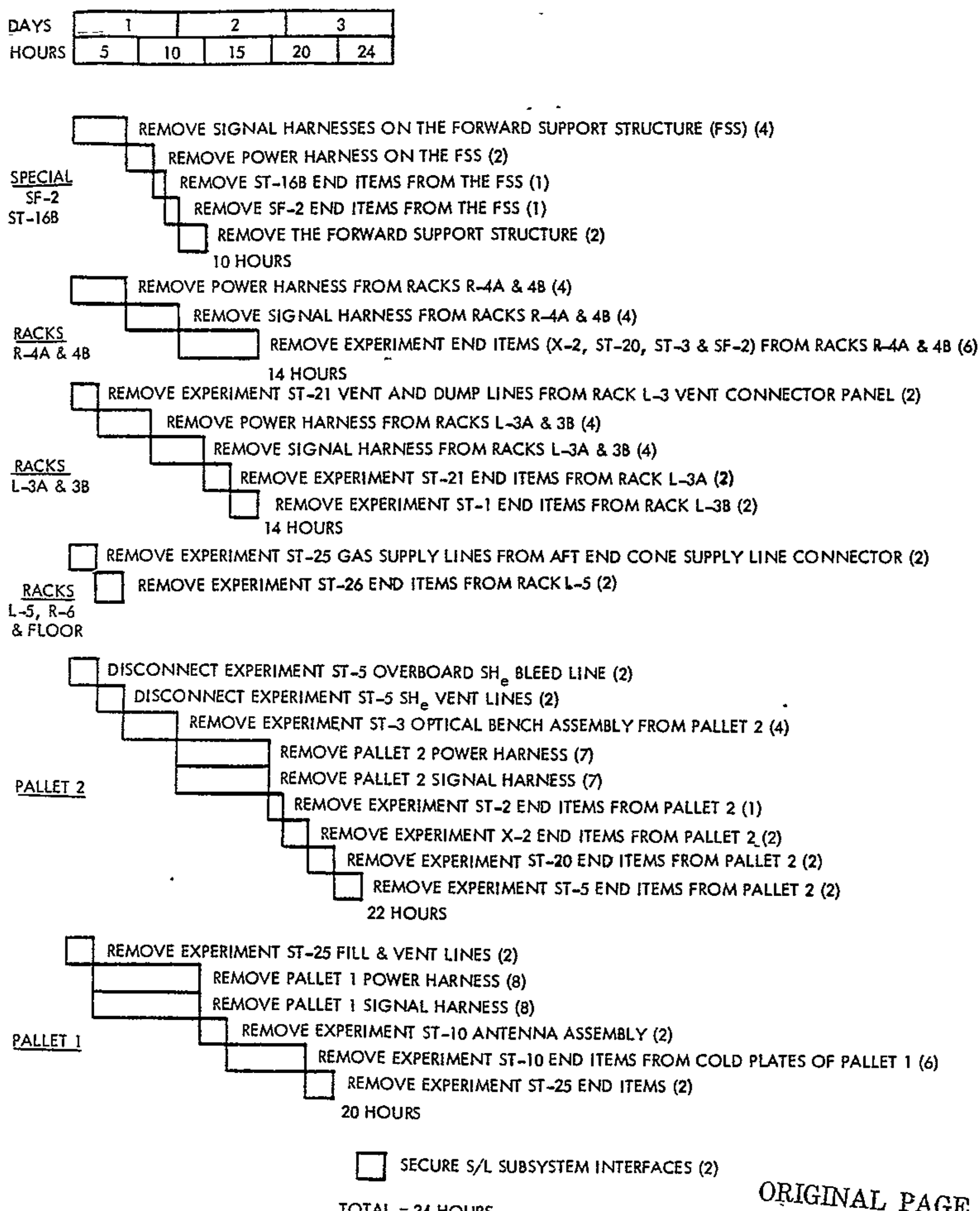

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Figure 2-14. ATL Payload Level IV Deintegration Rack 5/6/Floor Dedicated

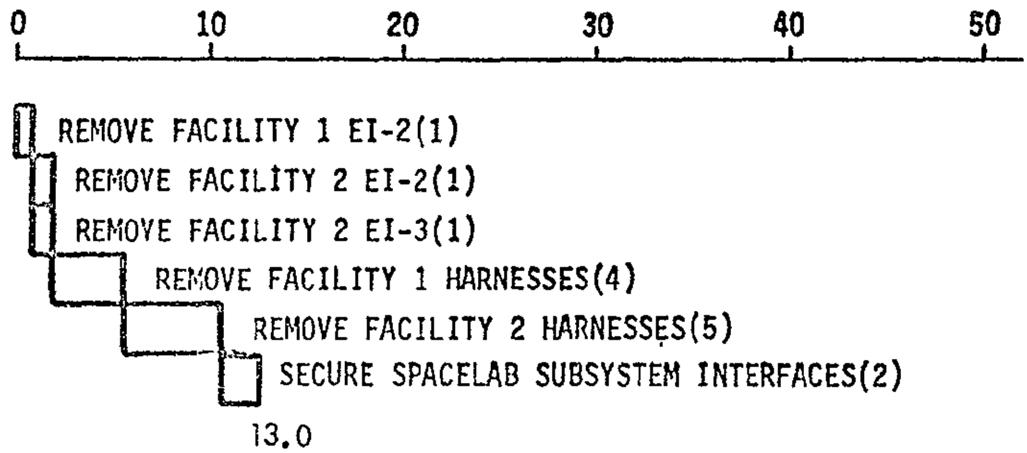

Figure 2-15. Space Processing Payload Level IV Deintegration - Dedicated Pallet

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Mini-Center 1 Option A1/A2

Quantity	Equipment Name		Unit Cost (SK)	Invlvm't Time(Days)	Prorated Cost/Flt($)
0	Vertical Sling Kit	612006	10.5	—	—
1	Feed Thru Protective Covers	612008	3.0	15	18.00
1	Pallet Segment Floor Covers	612010	3.5	15	21.00
1	Pallet Segment Support-Single	612013	47.0	15	282.00
0	Pallet Segment Support-Double	612013	—	—	—
1	Pallet Cover	612059	12.5	15	75.00
1	Pallet Platform-Single Pallet	612060	24.0	15	144.00
0	Pallet Platform-Double Pallet	612060	—	—	—
0	Rack, PSS Panel	612XXX	—	—	—
1	Desiccant Canister-Large	612067	11.5	15	69.00
1	Active Environmental Control Cart	612071	33.0	15	198.00
1	Road Transport Tie Down Kit	612106	10.5	15	63.00
1	Horizontal Sling Kit	612110	53.5	15	321.00
4	Trunnion Handling Fittings	612113	1.0	15	6.00
1	Transportation Instrumentation	614XXX	20.0	15	120.00
1	Optical Alignment Kit	612040	6.0	9	21.60
0	IPS Test and Checkout Kit	612208	120.0	—	—
0	Continuity Tester	613038	90.5	—	—
0	Ground/Bonding Tester	613039	31.0	—	—
0	Portable Leak Detector	612080	2.5	—	—
1	Freon Servicer	612084	25.0	9	90.00
1	Cable Sets and Adapters	613XXX	1.5/cable	9	5.40
1	Freon Leak Detector	612086	1.0	9	3.60
0	Operator's Console	612XXX	80.0	—	—
1	Refrigeration Unit	612115	101.1	9	363.96
1	GN-2 Service Cart	612XXX	50.0	9	180.00
0	Vacuum Pumping Unit	612XXX	25.0	—	—
1	Cleaning Kit	612XXX	11.5	9	41.40
1	Desiccant Drying Oven	614022	27.5	9	99.00
	TOTAL				2121.96

Table 2-6. Combined Astronomy, Pallet 1 Dedicated (Sheet 1 of 3)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Lead Center Option B-4

Quantity	Equipment Name		Unit Cost ($ K)	Invlvm't Time(Days)	Prorated Cost/Flt($)
0	Vertical Sling Kit	612006	10.5	—	—
5	Feed Thru Protective Covers	612008	3.0	28	168.00
4	Pallet Segment Floor Covers	612010	3.5	25	140.00
3	Pallet Segment Support-Single	612013	47 0	31	1748 40
1	Pallet Segment Support-Double	612013	94.0	26	977.60
5	Pallet Cover	612059	12.5	26	650.00
3	Pallet Platform-Single Pallet	612060	24.0	31	892.80
1	Pallet Platform-Double Pallet	612060	48.0	26	499.20
0	Rack, PSS Panel	612XXX	1.0	20	—
5	Desiccant Canister-Large	612067	11.5	26	598.00
1	Active Environmental Control Cart	612071	33.0	26	343.20
4	Road Transport Tie Down Kit	612106	10.5	26	436.80
1	Horizontal Sling Kit	612110	53.5	31	663.40
4	Trunnion Handling Fittings	612113	1.0	31	49.60
2	Transportation Instrumentation	614XXX	20.0	14	224.00
1	Optical Alignment Kit	612040	6.0	20	48.00
1	IPS Test and Checkout Kit	612208	120.0	20	960.00
0	Continuity Tester	613038	90.5	—	—
1	Ground/Bonding Tester	613039	31.0	20	248.00
0	Portable Leak Detector	612080	2.5	—	—
1	Freon Servicer	612084	25.0	20	200.00
1	Cable Sets and Adapters	613XXX	1.5/cable	20	12.00
1	Freon Leak Detector	612086	1.0	20	8.00
0	Operator's Console	612XXX	80.0	20	—
1	Refrigeration Unit	612115	101.1	20	808.80
1	GN-2 Service Cart	612XXX	50.0	28	560.00
1	Vacuum Pumping Unit	612XXX	25.0	20	200.00
1	Cleaning Kit	612XXX	11.5	20	92.00
1	Desiccant Drying Oven	614022	27.5	20	220.00
	TOTAL				10747.80

Table 2-6. Combined Astronomy, Pallet 1 Dedicated (Sheet 2 of 3)

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GSE REQUIREMENTS-COMBINED ASTRONOMY Location KSC Option C4

Quantity	Equipment Name		Unit Cost (\$ K)	Invlvm't Time (Days)	Prorated Cost/Flt 6)
0	Vertical Sling Kit	612006	10.5	—	—
5	Feed Thru Protective Covers	612008	3.0	20	120.00
4	Pallet Segment Floor Covers	612010	3.5	20	112.00
3	Pallet Segment Support-Single	612013	47.0	23	1297.20
1	Pallet Segment Support-Double	612013	94.0	23	864.80
5	Pallet Cover	612059	12.5	18	450.00
3	Pallet Platform-Single Pallet	612060	24.0	23	662.40
1	Pallet Platform-Double Pallet	612060	48.0	23	441.60
1	Rack, PSS Panel	612XXX	1.0	18	7.20
5	Desiccant Canister-Large	612067	11.5	18	414.00
1	Active Environmental Control Cart	612071	33.0	18	237.60
4	Road Transport Tie Down Kit	612106	10.5	18	302.40
1	Horizontal Sling Kit	612110	53.5	23	492.20
4	Trunnion Handling Fittings	612113	1.0	23	36.80
2	Transportation Instrumentation	614XXX	20.0	12	192.00
1	Optical Alignment Kit	612040	6.0	18	43.20
1	IPS Test and Checkout Kit	612208	120.0	18	864.00
0	Continuity Tester	613038	90.5	—	—
1	Ground/Bonding Tester	613039	31.0	18	223.20
0	Portable Leak Detector	612080	2.5	—	—
1	Freon Servicer	612084	25.0	18	180.00
1	Cable Sets and Adapters	613XXX	1.5/cable	18	10.80
1	Freon Leak Detector	612086	1.0	18	7.20
0	Operator's Console	612XXX	80.0	18	—
1	Refrigeration Unit	612115	101.1	18	727.92
1	GN-2 Service Cart	612XXX	50.0	18	360.00
1	Vacuum Pumping Unit	612XXX	25.0	18	180.00
1	Cleaning Kit	612XXX	11.5	18	82.80
1	Desiccant Drying Oven	614022	27.5	18	198.00
	TOTAL				8507.32

Table 2-6. Combined Astronomy, Pallet 1 Dedicated (Sheet 3 of 3)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Mini-Center 2 Option A1/A2

Quantity	Equipment Name		Unit Cost (\$ K)	Invlvm't Time (Days)	Prorated Cost/Flt 6)
0	Vertical Sling Kit	612006	10.5	—	—
3	Feed Thru Protective Covers	612008	3.0	19	68.40
3	Pallet Segment Floor Covers	612010	3.5	19	79.80
1	Pallet Segment Support-Single	612013	47.0	19	357.20
1	Pallet Segment Support-Double	612013	94.0	19	714.40
3	Pallet Cover	612059	12.5	19	285.00
1	Pallet Platform-Single Pallet	612060	24.0	19	182.40
1	Pallet Platform-Double Pallet	612060	48.0	19	364.80
1	Rack, PSS Panel	612XXX	1.0	12	4.80
3	Desiccant Canister-Large	612067	11.5	19	262.20
1	Active Environmental Control Cart	612071	33.0	19	250.80
1	Road Transport Tie Down Kit	612106	10.5	19	79.80
1	Horizontal Sling Kit	612110	53.5	19	406.60
4	Trunnion Handling Fittings	612113	1.0	19	30.40
1	Transportation Instrumentation	614XXX	20.0	19	152.00
1	Optical Alignment Kit	612040	6.0	12	28.80
1	IPS Test and Checkout Kit	612208	120.0	12	576.00
0	Continuity Tester	613038	90.5	—	—
0	Ground/Bonding Tester	613039	31.0	—	—
0	Portable Leak Detector	612080	2.5	—	—
1	Freon Servicer	612084	25.0	12	120.00
1	Cable Sets and Adapters	613XXX	1.5/cable	12	7.20
1	Freon Leak Detector	612086	1.0	12	4.80
1	Operator's Console	612XXX	80.0	12	384.00
1	Refrigeration Unit	612115	101.1	12	485.28
0	GN-2 Service Cart	612XXX	50.0	—	—
1	Vacuum Pumping Unit	612XXX	25.0	12	120.00
1	Cleaning Kit	612XXX	11.5	12	55.20
1	Desiccant Drying Oven	614022	27.5	12	132.00
	TOTAL				5151.88

Table 2-7. Combined Astronomy, Pallet 3/4 Dedicated (Sheet 1 of 3)

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GSE REQUIREMENTS-COMBINED ASTRONOMY Lead Location Center Option B4

Quantity	Equipment Name		Unit Cost ($ K)	Invlvm't Time (Days)	Prorated Cost/Flt($)
0	Vertical Sling Kit	612006	10.5	—	—
5	Feed Thru Protective Covers	612008	3.0	28	168.00
4	Pallet Segment Floor Covers	612010	3.5	25	140.00
3	Pallet Segment Support-Single	612013	47.0	31	1748.40
1	Pallet Segment Support-Double	612013	94.0	31	1165.60
5	Pallet Cover	612059	12.5	26	650.00
3	Pallet Platform-Single Pallet	612060	24.0	31	892.80
1	Pallet Platform-Double Pallet	612060	48.0	31	595.20
0	Rack, PSS Panel	612XXX	1.0	20	—
5	Desiccant Canister-Large	612067	11.5	26	598.00
1	Active Environmental Control Cart	612071	33.0	26	343.20
4	Road Transport Tie Down Kit	612106	10.5	26	436.80
1	Horizontal Sling Kit	612110	53.5	31	663.40
4	Trunnion Handling Fittings	612113	1.0	31	49.60
2	Transportation Instrumentation	614XXX	20.0	14	224.00
1	Optical Alignment Kit	612040	6.0	20	48.00
1	IPS Test and Checkout Kit	612208	120.0	20	960.00
0	Continuity Tester	613038	90.5	—	—
1	Ground/Bonding Tester	613039	31.0	20	248.00
0	Portable Leak Detector	612080	2.5	—	—
1	Freon Servicer	612084	25.0	20	200.00
1	Cable Sets and Adapters	613XXX	1.5/cable	20	12.00
1	Freon Leak Detector	612086	1.0	20	8.00
0	Operator's Console	612XXX	80.0	20	—
1	Refrigeration Unit	612115	101.1	20	808.00
1	GN-2 Service Cart	612XXX	50.0	20	400.00
1	Vacuum Pumping Unit	612XXX	25.0	20	200.00
1	Cleaning Kit	612XXX	11.5	20	92.00
1	Desiccant Drying Oven	614022	27.5	20	220.00
	TOTAL				10871.00

Table 2-7. Combined Astronomy, Pallet 3/4 Dedicated (Sheet 2 of 3)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location KSC Option C4

Quantity	Equipment Name		Unit Cost ($ K)	Invlvm't Time (Days)	Prorated Cost/Flt($)
0	Vertical Sling Kit	612006	10.5	—	—
5	Feed Thru Protective Covers	612008	3.0	20	120.00
4	Pallet Segment Floor Covers	612010	3.5	20	112.00
3	Pallet Segment Support-Single	612013	47.0	23	1297.20
1	Pallet Segment Support-Double	612013	94.0	18	676.80
5	Pallet Cover	612059	12.5	18	450.00
3	Pallet Platform-Single Pallet	612060	24.0	23	662.40
1	Pallet Platform-Double Pallet	612060	48.0	18	345.60
0	Rack, PSS Panel	612XXX	1.0	18	—
5	Desiccant Canister-Large	612067	11.5	18	414.00
1	Active Environmental Control Cart	612071	33.0	18	237.60
4	Road Transport Tie Down Kit	612106	10.5	18	302.40
1	Horizontal Sling Kit	612110	53.5	23	492.20
4	Trunnion Handling Fittings	612113	1.0	23	36.80
2	Transportation Instrumentation	614XXX	20.0	12	192.00
1	Optical Alignment Kit	612040	6.0	18	43.20
1	IPS Test and Checkout Kit	612208	120.0	18	864.00
0	Continuity Tester	613038	90.5	—	—
1	Ground/Bonding Tester	613039	31.0	18	223.20
0	Portable Leak Detector	612080	2.5	—	—
1	Freon Servicer	612084	25.0	18	180.00
1	Cable Sets and Adapters	613XXX	1.5/cable	18	10.80
1	Freon Leak Detector	612086	1.0	18	7.20
0	Operator's Console	612XXX	80.0	18	—
1	Refrigeration Unit	612115	101.1	18	727.92
1	GN-2 Service Cart	612XXX	50.0	23	460.00
1	Vacuum Pumping Unit	612XXX	25.0	18	180.00
1	Cleaning Kit	612XXX	11.5	18	82.80
1	Desiccant Drying Oven	614022	27.5	18	198.00
	TOTAL				8316.12

Table 2-7. Combined Astronomy, Pallet 3/4 Dedicated (Sheet 3 of 3)

GSE REQUIREMENTS-LIFE SCIENCES   Location Distrib. Site 8   Option A-1

Quantity	Equipment Name		Unit Cost ($)	Invlvm't Time(Days)	Prorated Cost/Flt($)
1	Transport Dolly, Rack & Floor	612002A	33,000	12	158.4
2	Vertical Sling Kit, Rack & Floor	612006A	10,500	10	84.0
	Horizontal Sling Kit, Rack & Floor	612110A			
1	Rack & Floor Shipping Cover	612047A	8,000	15	48.0
1	Rack & Floor Transport Platform	612048A	24,000	17	163.2
1	Rack & Floor Support Braces Kit	612049A	2,500	16	16.0
	Double Rack Hndlg C/O & Tnspt Kt	612050A	9,000		
	Single Rack Hndlg C/O & Tnspt Kt	612065A	9,000		
	Desiccant Canister, Med.,Dbl Rack	612068A	9,000		
4	Desiccant Canister, Small, Sngl Rk	612069A	7,000	16	179.2
	Active Environ. Control Cart	612071A	33,000		
1	Road Tiedown Kit, U.S.	612106A	10,500	16	67.2
	Cargo Lift Trailer, Rack & Floor	614013			
	Adapter Kit Cargo Lift Trailer	614014			
1	Transportation Instrumentation	614XXX	20,000	16	128.0
1	Operators Checkout Console	612XXX	80,000	10	320.0
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
	Peripheral Checkout Equipment	612XXX			
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
	Optical Alignment Kit	612040			
1	Continuity Tester, Electrical	613038	90,500	10	362.0
1	Grounding/Bonding Tester	613039	31,000	10	124.0
	Portable Leak Detection Unit	612080A			
	Freon Leak Detector(Rack Refrig/ Freezer	612XXX			
1	Vacuum Pumping Unit	612XXX	25,000	10	100.0
1	Rack Cooling Unit (Support C/O)	612XXX	50,500	10	202.0
	Gas, Bottles, Supply Unit	612XXX	50,000		
	GN-2 Service Set	614XXX	50,000		
1	Cleaning Kit	612114A	11,500	9	41.4
	Desiccant Drying Kit/Oven	614022	27,500		
	Human Physiological Simulator	—			
	Frog Simulator	—			
	Rat Simulator	—			
	Oculographic Simulator	—			
	Mass Spec Analog Data Simulator	—			
	Rat Temperature Output Simulator	—			
	Monkey Physiological Simulator	—		5	
		TOTAL			1993 4

Table 2-8. Life Sciences Payload - Dedicated Racks 11/12/Floor
(Sheet 1 of 5)

GSE REQUIREMENTS-LIFE SCIENCES   Location Lead Center   Option B1/B3

Quantity	Equipment Name		Unit Cost ($)	Invlvm't Time(Days)	Prorated Cost/Flt($)
1	Transport Dolly, Rack & Floor	612002A	33,000	29	382.8
1	Vertical Sling Kit, Rack & Floor	612006A	10,500	26	109.2
	Horizontal Sling Kit, Rack & Floor	612110A			
1	Rack & Floor Shipping Cover	612047A	8,000	24	76.8
1	Rack & Floor Transport Platform	612048A	24,000	29	278.4
1	Rack & Floor Support Braces Kit	612049A	2,500	29	29.0
	Double Rack Hndlg C/O & Tnspt Kt	612050A	9,000		
	Single Rack Hndlg C/O & Tnspt Kt	612065A	9,000		
6	Desiccant Canister, Med.,Dbl Rack	612068A	9,000	25	540.0
4	Desiccant Canister, Small, Sngl Rk	612069A	7,000	25	280.0
1	Active Environ. Control Cart	612071A	33,000	25	330.0
1	Road Tiedown Kit, U.S.	612106A	10,500	24	100.8
	Cargo Lift Trailer, Rack & Floor	614013			
	Adapter Kit Cargo Lift Trailer	614014			
1	Transportation Instrumentation	614XXX	20,000	25	200.0
1	Operators Checkout Console	612XXX	80,000	19	608.0
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
	Peripheral Checkout Equipment	612XXX			
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
	Optical Alignment Kit	612040			
1	Continuity Tester, Electrical	613038	90,500	19	687.8
1	Grounding/Bonding Tester	613039	31,000	19	235.6
	Portable Leak Detection Unit	612080A			
	Freon Leak Detector(Rack Refrig/ Freezer	612XXX			
1	Vacuum Pumping Unit	612XXX	25,000	19	190.0
1	Rack Cooling Unit (Support C/O)	612XXX	50,500	19	383.8
1	Gas, Bottles, Supply Unit	612XXX	50,000	26	520.0
1	GN-2 Service Set	614XXX	50,000	19	380.0
1	Cleaning Kit	612114A	11,500	19	87.4
	Desiccant Drying Kit/Oven	614022	27,500		
1	Human Physiological Simulator	—		7	
1	Frog Simulator	—		6	
1	Rat Simulator	—		11	
1	Oculographic Simulator	—		10	
1	Mass Spec Analog Data Simulator	—		9	
1	Rat Temperature Output Simulator	—		8	
1	Monkey Physiological Simulator	—		5	
		TOTAL			5419 6

Table 2-8. Life Sciences Payload - Dedicated Racks 11/12/Floor
(Sheet 2 of 5)

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Space Division

GSE REQUIREMENTS-LIFE SCIENCES — Location: Lead Center — Option: B4

Quantity	Equipment Name		Unit Cost ($)	Invlvm't Time (Days)	Prorated Cost/Flt($)
1	Transport Dolly, Rack & Floor	612002A	33,000	33	435.6
1	Vertical Sling Kit, Rack & Floor	612006A	10,500	30	126.0
	Horizontal Sling Kit, Rack & Floor	612110A			
1	Rack & Floor Shipping Cover	612047A	8,000	28	89.6
1	Rack & Floor Transport Platform	612048A	24,000	33	316.8
1	Rack & Floor Support Braces Kit	612049A	2,500	33	33.0
	Double Rack Hndlg C/O & Tnspt Kt	612050A	9,000		
	Single Rack Hndlg C/O & Tnspt Kt	612065A	9,000		
6	Desiccant Canister, Med., Dbl Rack	612068A	9,000	29	626.4
4	Desiccant Canister, Small, Sngl Rk	612069A	7,000	29	324.8
1	Active Environ. Control Cart	612071A	33,000	29	382.8
1	Road Tiedown Kit, U.S.	612106A	10,500	28	117.6
	Cargo Lift Trailer, Rack & Floor	614013			
	Adapter Kit Cargo Lift Trailer	614014			
1	Transportation Instrumentation	614XXX	20,000	29	232.0
1	Operators Checkout Console	612XXX	80,000	23	736.0
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
	Peripheral Checkout Equipment	612XXX			
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
	Optical Alignment Kit	612040			
1	Continuity Tester, Electrical	613038	90,500	23	832.6
1	Grounding/Bonding Tester	613039	31,000	23	285.2
	Portable Leak Detection Unit	612080A			
	Freon Leak Detector(Rack Refrig/ Freezer	612XXX			
1	Vacuum Pumping Unit	612XXX	25,000	23	230.0
1	Rack Cooling Unit (Support C/O)	612XXX	50,500	23	464.6
1	Gas, Bottles, Supply Unit	612XXX	50,000	30	600.0
1	GN-2 Service Set	614XXX	50,000	23	460.0
1	Cleaning Kit	612114A	11,500	23	105.8
	Desiccant Drying Kit/Oven	614022	27,500		
1	Human Physiological Simulator	—		5	
1	Frog Simulator	—		5	
1	Rat Simulator	—		7	
1	Oculographic Simulator	—		7	
1	Mass Spec Analog Data Simulator	—		6	
1	Rat Temperature Output Simulator	—		6	
1	Monkey Physiological Simulator			4	
		TOTAL			6398.8

Table 2-8. Life Sciences Payload - Dedicated Racks 11/12/Floor (Sheet 3 of 5)

GSE REQUIREMENTS-LIFE SCIENCES — Location: KSC — Option: C1/C3

Quantity	Equipment Name		Unit Cost ($)	Invlvm't Time (Days)	Prorated Cost/Flt($)
1	Transport Dolly, Rack & Floor	612002A	33,000	21	277.2
1	Vertical Sling Kit, Rack & Floor	612006A	10,500	24	100.8
	Horizontal Sling Kit, Rack & Floor	612110A			
1	Rack & Floor Shipping Cover	612047A	8,000	16	51.2
1	Rack & Floor Transport Platform	612048A	24,000	21	201.6
1	Rack & Floor Support Braces Kit	612049A	2,500	21	21.0
	Double Rack Hndlg C/O & Tnspt Kt	612050A	9,000		
	Single Rack Hndlg C/O & Tnspt Kt	612065A	9,000		
6	Desiccant Canister, Med., Dbl Rack	612068A	9,000	17	367.2
4	Desiccant Canister, Small, Sngl Rk	612069A	7,000	17	190.4
1	Active Environ. Control Cart	612071A	33,000	17	224.4
1	Road Tiedown Kit, U.S.	612106A	10,500	16	67.2
	Cargo Lift Trailer, Rack & Floor	614013			
	Adapter Kit Cargo Lift Trailer	614014			
1	Transportation Instrumentation	614XXX	20,000	17	136.0
1	Operators Checkout Console	612XXX	80,000	17	544.0
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
	Peripheral Checkout Equipment	612XXX			
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
	Optical Alignment Kit	612040			
1	Continuity Tester, Electrical	613038	90,500	17	615.4
1	Grounding/Bonding Tester	613039	31,000	17	210.8
	Portable Leak Detection Unit	612080A			
	Freon Leak Detector(Rack Refrig/ Freezer	612XXX			
1	Vacuum Pumping Unit	612XXX	25,000	17	170.0
1	Rack Cooling Unit (Support C/O)	612XXX	50,500	17	343.4
1	Gas, Bottles, Supply Unit	612XXX	50,000	24	480.0
1	GN-2 Service Set	614XXX	50,000	17	340.0
1	Cleaning Kit	612114A	11,500	17	78.2
	Desiccant Drying Kit/Oven	614022	27,500		
1	Human Physiological Simulator	—		6	
1	Frog Simulator	—		5	
1	Rat Simulator	—		10	
1	Oculographic Simulator	—		9	
1	Mass Spec Analog Data Simulator	—		8	
1	Rat Temperature Output Simulator	—		7	
1	Monkey Physiological Simulator			4	
		TOTAL			4418 8

Table 2-8. Life Sciences Payload - Dedicated Racks 11/12/Floor (Sheet 4 of 5)

GSE REQUIREMENTS-LIFE SCIENCES Location KSC Option C4

Quantity	Equipment Name		Unit Cost ($)	Invlvm't Time(Days)	Prorated Cost/Flt($)
1	Transport Dolly, Rack & Floor	612002A	33,000	25	330.0
1	Vertical Sling Kit, Rack & Floor	612006A	10,500	28	117.6
	Horizontal Sling Kit, Rack & Floor	612110A			
1	Rack & Floor Shipping Cover	612047A	8,000	20	64.0
1	Rack & Floor Transport Platform	612048A	24,000	25	240 0
1	Rack & Floor Support Braces Kit	612049A	2,500	25	25.0
	Double Rack Hndlg C/O & Tnspt Kt	612050A	9,000		
	Single Rack Hndlg C/O & Tnspt Kt	612065A	9,000		
1	Desiccant Canister, Med.,Dbl Rack	612068A	9,000	21	75.6
4	Desiccant Canister, Small, Sngl Rk	612069A	7,000	21	235 2
1	Active Environ. Control Cart	612071A	33,000	21	277.2
1	Road Tiedown Kit, U.S.	612106A	10,500	20	84 0
	Cargo Lift Trailer, Rack & Floor	614013			
	Adapter Kit Cargo Lift Trailer	614014			
1	Transportation Instrumentation	614XXX	20,000	21	168.0
1	Operators Checkout Console	612XXX	80,000	21	672.0
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
	Peripheral Checkout Equipment	612XXX			
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
	Optical Alignment Kit	612040			
1	Continuity Tester, Electrical	613038	90,500	21	760.2
1	Grounding/Bonding Tester	613039	31,000	21	260.4
	Portable Leak Detection Unit	612080A			
	Freon Leak Detector(Rack Refrig/ Freezer	612XXX			
1	Vacuum Pumping Unit	612XXX	25,000	21	210 0
1	Rack Cooling Unit (Support C/O)	612XXX	50,500	21	424.2
1	Gas, Bottles, Supply Unit	612XXX	50,000	28	560.0
1	GN-2 Service Set	614XXX	50,000	21	420.0
1	Cleaning Kit	612114A	11,500	21	96.6
	Desiccant Drying Kit/Oven	614022	27,500		
1	Human Physiological Simulator	—		4	
1	Frog Simulator	—		4	
1	Rat Simulator	—		6	
1	Oculographic Simulator	—		6	
1	Mass Spec Analog Data Simulator	—		5	
1	Rat Temperature Output Simulator	—		5	
1	Monkey Physiological Simulator	TOTAL		3	5020.0

Table 2-8. Life Sciences Payload - Dedicated Racks 11/12/Floor (Sheet 5 of 5)

Table 2-9. ATL Payload, Dedicated Pallet 1

Minicenter

Quantity	Equipment Name		Unit Cost ($K)	Invlvm't Time(Days)	Prorated Cost/Flt($)
0	Double Rack Handling Kit	613050	9.0	0	0
1	Vertical Sling Kit	612006A	10.5	24	100.80
1	Feed Thru Prot. Covers	612008	3.0	19	22.80
1	Pallet Seg. Floor Covers	612010	3.5	24	33.60
1	Pallet Segment Support	612013	47.0	27	507.60
1	Rack/Floor Shipping Cover	612047	8.0	22	70.40
1	Rack/Floor Transport Platform	612048	1.0	27	10.80
1	Rack/Floor Support Braces	612049	2.5	27	27.00
1	Pallet Cover	612059	12.5	22	110.00
1	Pallet Platform	612060	24.0	22	211.20
1	Desiccant Canister Large	612067	11.5	22	101.20
1	Desiccant Canister Medium	612068	9.0	22	79.20
1	Active Environment Cart	612071A	33.0	22	290.40
1	Road Tiedown Kit	612106	10.5	22	92.40
1	Horizontal Sling Kit	612110	53.5	24	513.60
4	Trunnion Handling Fittings	612113	1.0	24	38.40
1	Refrigeration Unit	612115	101.1	16	647.04
1	Rack Cooling Unit	612XXX	50.5	16	323.20
1	Cleaning Kit	612114	11.5	16	73.60
1	Desiccant Drying Oven	614002	27.5	16	176.00
1	Grounding/Bonding Tester	613039	31.0	16	198.40
1	Cable Sets and Adapters				
1	Portable Leak Detector	612080	2.5	16	16.00
1	Freon Servicer	612084	25.0	16	160.00
1	Freon Leak Detector	612086	1.0	16	6.40
1	Optical Alignment Kit	612040	6.0	16	38.40
1	Transport Instrumentation	614XXX	20.0	19	152.00
1	Operator's Console	612XXX	80.0	16	512.00
0	Optical Bench Support Cart	-		0	
0	Inert Gas Cart	-		0	
0	FSS Holding Jig and Cover	-		0	
0	Broad Band Illuminator	-		0	
0	Antenna Support Cart	-		0	
		TOTAL			4512.44

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Table 2-10. GSE Proration Space Processing Payload, Dedicated Pallet (Sheet 1 of 2)

Lead Center

Quantity	Equipment Name		Unit Cost (SK)	Invlvm't Time (Days)	Prorated Cost/Flt (S)
1	Feedthru Covers	612008	3.0	24	28.80
1	Pallet Seg. Floor Covers	612010	3.5	19	26.60
1	Pallet Seg. Support	612013	47.0	24	451.20
1	Pallet Cover	612059	12.5	21	105.00
1	Pallet Platform	612060	24.0	24	230.40
3	Desiccant Canister, Large	612067	11.5	21	289.80
1	Road Tiedown Kit	612106	10.5	21	88.20
1	Horizontal Sling	612110	53.5	18	385.20
4	Trunnion Handling Fittings	612113	1.0	18	28.80
1	Transport Instrumentation		20.0	21	168.00
1	Ground/Bond Tester	613039	31.0	21	260.40
6	Cable Set and Adapters		1.5	11	39.60
1	Portable Leak Detector	612080	2.5	11	11.00
1	Freon Servicer	612084	25.0	11	110.00
1	Freon Leak Detector	612086	1.0	11	4.40
1	Refrig Unit	612115	101.0	11	444.40
1	Cleaning Kit	612114	11.5	24	110.40
1	Desiccant Oven	614022	27.5	6	66.00
1	Operator's Console		80.0	21	672.00
1	PSS Panel Rack		1.0	21	8.40
1	Active ECS Cart	612071	33.0	21	277.20
		TOTAL			3805.80

Table 2-10. GSE Proration Space Processing Payload, Dedicated Pallet (Sheet 2 of 2)

KSC

Quantity	Equipment Name		Unit Cost (S)	Involvm't Time (Days)	Prorated Cost/Flt ($)
1	Feedthru Covers	612008	3.0	16	19.2
1	Pallet Seg. Floor Covers	612010	3.5	15	21.0
1	Pallet Seg. Support	612013	47.0	16	300.8
1	Pallet Cover	612059	12.5	12	60.0
1	Pallet Platform	612060	24.0	16	153.6
3	Desiccant Canister, Large	612067	11.5	12	165.6
1	Road Tiedown Kit	612106	10.5	12	50.4
1	Horizontal Sling	612110	53.5	15	321.0
4	Trunnion Handling Fittings	612113	1.0	15	24.0
1	Transport Instrumentation		20.0	15	120.0
1	Ground/Bond Tester	613039	31.0	3	37.2
6	Cable Set and Adapters		1.5	7	25.2
1	Portable Leak Detector	612080	2.5	2	2.0
1	Freon Servicer	612084	25.0	8	80.0
1	Freon Leak Detector	612086	1.0	2	0.8
1	Refrig Unit	612115	101.0	8	323.2
1	Cleaning Kit	612114	11.5	14	64.4
1	Desiccant Oven	614022	27.5	2,	22.0
1	Operator's Console		80.0	9	288.0
1	PSS Panel Rack		1.0	9	3.6
1	Active ECS Cart	612071	33.0	12	158.4
		TOTAL			2240.4

Dedication Break-Even Analysis - Purchased Equipment Approach

In the treatment of the cost tradeoff of dedicated Spacelab hardware, three possible approaches were considered. In this section, it was assumed that a prospective Principal Investigator would consider actual purchase of the flight equipment on a cash basis. He would have exclusive use of the equipment for the entire Shuttle program (assumed to be for 10 years). He could fly his payload at any rate he desired (or at the rate dictated by space available), and between flights, the equipment would sit idle, fully equipped with his experiment equipment. During this time, modifications, repairs, etc. could be carried out at leisure. If the PI completed all the missions needed to accomplish his program objectives, he would be free to sell or lease the Spacelab equipment or keep it, since he held full title to it.

This approach addresses the question "How many flights must I fly, as PI, to make this approach more economical and cost effective than leasing the equipment from NASA based on prorated costs and going through the full integration/deintegration cycle for each flight?" To determine this, a break-even analysis was performed, charting the net effect of fixed costs per flight and those costs which are sensitive to flight rate. Tables 2-11 through 2-16 presents the fixed costs.

In this approach, the cost of the flight hardware is sensitive to flight rate and is calculated based on the following costs for the dedicated hardware complements:

Combined Astronomy - Pallet 1

1 Pallet	$3,022,000
1 SIPS with canisters	1,500,000
3 RAUs	429,000
2 Interconnect Stations	6,000
1 EPDB	88,000
1 Freon Pump/Accumulator Package	110,000
1 AC Inverter	100,000
2 Coldplates	54,000
TOTAL COST	$5,309,000

Combined Astronomy - Pallets 3 and 4

2 Pallets	$6,044,000
1 RAU	143,000
1 EPDB	88,000
1 Interconnect Station	3,000
1 Coldplate	27,000
TOTAL	$6,305,000

Life Sciences - Racks 11, 12 and Floor

2 Single Racks - - - - - - - - - -	$182,000
2 EPSPs - - - - - - - - - - -	176,000
1 EPDB and CACB - - - - - - -	91,000
1 RAU - - - - - - - - - - -	143,000
1 Floor Segment, Double - - - - -	59,000
TOTAL	$651,000

ATL Payload - Racks 5, 6, and Floor

2 Single Racks - - - - - - - -	$182,000
2 EPSP's - - - - - - - - - - -	176,000
2 RAUs - - - - - - - - - - -	286,000
1 Floor Segment, Double - - - - -	59,000
TOTAL	$703,000

ATL Payload - Pallet 1

1 Pallet - - - - - - - - - - -	$3,022,000
6 Coldplates - - - - - - - - -	1,620,000
1 RAU - - - - - - - - - - -	143,000
1 Interconnect Station - - - - - -	3,000
1 EPDB - - - - - - - - - - -	88,000
TOTAL	$4,876,000

Space Processing - Pallet

1 Pallet - - - - - - - - - - -	$3,022,000
1 RAU - - - - - - - - - - -	143,000
1 EPDB - - - - - - - - - - -	88,000
4 Coldplates - - - - - - - - -	108,000
1 Inverter - - - - - - - - - -	100,000
1 Freon pump/accumulator package - -	110,000
1 Interconnect Station - - - - - -	3,000
1 Experiment Heat Exchanger - - - -	150,000
TOTAL	$3,724,000

Table 2-11. Combined Astronomy, Dedicated Pallet 1
(Cost in 1977 $)

Cost Element \ Concept	A2	B2	B4	C2	C4
MANPOWER					
Installation and Experiment Test, Direct Labor (3,4,5,6)	114120	114120	86360	114120	86360
Payload Testing, Direct Labor (7,8,9)	34460	33190	24940	33190	24940
Installation & Test Support (3 thru 9)	5880	7140	6160	14280	12320
Level III/II/I Integration and Post Flight Support (11,12,13,15)	25920	25920	25920	25920	25920
Deintegration, Direct Labor (16)	8350	8350	8350	8350	8350
Deintegration Support (16)	1680	1680	1680	1680	1680
TOTAL MANPOWER	190410	190400	153410	197540	159570
TDY EXPENSE					
Installation and Exp Test, Direct Labor	4425	10111	12336	38475	24675
Payload Testing Direct Labor	12975	6150	4800	12300	9600
Level III/II/I Integration and Post Flight Support	9000	9000	9000	9000	9000
Deintegration, Direct Labor	1950	1950	1950	1950	1950
TOTAL TDY	28350	27211	28086	61725	45225
TRANSPORTATION					
To/From Level IV	44500	22000	22000	3000	3000
GSE PRORATION	17065	14781	12663	12840	10974
TOTAL	280326	254392	216159	275105	218769

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Table 2-12. Combined Astronomy, Dedicated Pallet 3/4
(Cost in 1977 $)

Cost Element \ Concept	A2	B2	B4	C2	C4
MANPOWER					
Installation and Experiment Test, Direct Labor (3,4,5,6)	101670	101670	73060	101670	73060
Payload Testing, Direct Labor (7,8,9)	34460	33190	24940	33190	24940
Installation & Test Support (3 thru 9)	5880	7140	6160	14280	12320
Level III/II/I Integration and Post Flight Support (11,12,13,15)	25920	25920	25920	25920	25920
Deintegration, Direct Labor (16)	8350	8350	8350	8350	8350
Deintegration Support (16)	1680	1680	1680	1680	1680
TOTAL MANPOWER	177960	177950	140110	185090	146270
TDY EXPENSE					
Installation and Exp. Test, Direct Labor	6525	12211	10443	40725	20887
Payload Testing, Direct Labor	12975	6150	4800	12300	9600
Level III/II/I Integration and Post Flight Support	9000	9000	9000	9000	9000
Deintegration, Direct Labor	1950	1950	1950	1950	1950
TOTAL TDY	30450	29311	26193	63975	41437
TRANSPORTATION					
To/From Level IV	40500	22000	22000	3000	3000
GSE PRORATION	15818	16126	13783	13013	11122
TOTAL	264728	245387	202086	265078	201829

Table 2-13. Life Sciences, Dedicated Rack 11/12 Floor (Cost in 1977 $)

Cost Element \ Concept	A1	A3	B1	B3	B4	C1	C3	C4
MANPOWER								
Installation and Experiment Test, Direct Labor (3 → 6)								
Site 1	15540	15540						
Site 2	14190	14190						
Site 3	11730	11730						
Site 4	7040	7040						
Site 5	4550	4550						
Site 6	15945	15945						
Site 7	15150	15150						
Site 8	19995	19995						
Lead Center	—	—	73980	73980	67450	73980	73980	67450
Payload Testing, Direct Labor (7,8,9)	—	14200	—	14200	9720	—	14200	9720
Installation & Test Support (3 → 9)	—	4760	2135	3045	3342	8540	12180	13370
Level III/II/I Integration and Post Flight Support (10,11,12,13,15)	48000	48000	48000	48000	38400	48000	48000	38400
Deintegration, Direct Labor (16)	16200	16200	16200	16200	16200	16200	16200	16200
Deintegration Support (16)	2100	2100	2100	2100	2100	2100	2100	2100
TOTAL MANPOWER	170440	189400	142415	157525	137212	148820	166660	147240
TDY EXPENSE								
Installation and Exp. Test, Direct Labor	—	—	10174	10174	9074	19950	19950	18150
Payload Testing, Direct Labor	—	1050	—	2175	1500	—	4350	3000
Level III/II/I Integration Support	29700	29700	29700	29700	28350	29700	29700	28350
Post Flight Support	4050	4050	4050	4050	4050	4050	4050	4050
Deintegration, Direct Labor	5100	5100	5100	5100	5100	5100	5100	5100
TOTAL TDY	38850	39900	49024	51199	48074	58800	63150	58650
TRANSPORTATION								
To/From Level IV	70000	70000	17000	17000	17000	3000	3000	3000
GSE PRORATION	15820	16973	6340	7493	7275	4419	5572	6274
GRAND TOTAL	295110	316273	214779	233217	209561	215039	238382	215164

Table 2-14. ATL, Dedicated Rack 5/6/Floor (Cost in 1977 $)

Cost Element \ Concept	A1	A3	B1	B3	B4	C1	C3	C4
MANPOWER								
Installation and Experiment, Direct Labor (3,4,5,6)	139780	139780	139780	139780	96980	139780	139780	96980
Payload Testing, Direct Labor (7,8,9)	—	5950	—	5950	4470	—	5950	4470
Installation Test Support (3 thru 9)	—	2590	3045	3553	3553	3553	14210	14210
Level III/II/I Integration and Post Flight Support (10 thru 15)	48000	48000	48000	48000	38400	48000	48000	38400
Deintegration, Direct Labor (16)	13440	13440	13440	13440	13440	13440	13440	13440
Deintegration Support (16)	1680	1680	1680	1680	1680	1680	1680	1680
TOTAL MANPOWER	202900	211440	205945	212403	158523	206453	223060	169180
TDY EXPENSE								
Installation and Exp. Test, Direct Labor	9450	9450	18074	18074	13181	36150	36150	26362
Payload Testing, Direct Labor	—	1950	—	976	750	—	1950	1500
Level III/II/I Integration Support	29700	29700	29700	29700	28350	29700	29700	28350
Post Flight Support	4050	4050	4050	4050	4050	4050	4050	4050
Deintegration, Direct Labor	4050	4050	4050	4050	4050	4050	4050	4050
TOTAL TDY	47250	49200	55874	56850	50381	73950	75900	64312
TRANSPORTATION								
To/From Level IV	34000	34000	14000	14000	14000	3000	3000	3000
GSE PRORATION	10184	10184	8167	8167	8167	5978	5978	5978
GRAND TOTAL	294334	304824	283986	291420	231071	289381	307938	242470

Table 2-15. ATL, Dedicated Pallet 1 (Cost in 1977 $)

Cost Element \ Concept	A1	A3	B1	B3	B4	C1	C3	C4
MANPOWER								
Installation and Experiment Test, Direct Labor (3,4,5,6)	131980	131980	131980	131980	88930	131980	131980	88930
Payload Testing, Direct Labor (7,8,9)	—	5950	—	5950	4470	—	5950	4470
Installation and Test Support (3 thru 9)	—	2590	3045	3553	3553	3553	14210	14210
Level III/II/I Integration and Post Flight Support (10 thru 15)	48000	48000	48000	48000	38400	48000	48000	38400
Deintegration, Direct Labor (16)	12000	12000	12000	12000	12000	12000	12000	12000
Deintegration Support (16)	1680	1680	1680	1680	1680	1680	1680	1680
TOTAL MANPOWER	193660	202200	196705	203163	149033	197213	213820	159690
TDY EXPENSE								
Installation and Exp. Test, Direct Labor	8935	8935	17044	17044	12224	34087	34087	24450
Payload Testing, Direct Labor	—	1950	—	976	750	—	1950	1500
Level III/II/I Integration Support	29700	29700	29700	29700	28350	29700	29700	28350
Post Flight Support	4050	4050	4050	4050	4050	4050	4050	4050
Deintegration, Direct Labor	3600	3600	3600	3600	3600	3600	3600	3600
TOTAL TDY	46285	48235	54394	55370	48974	71437	73387	61950
TRANSPORTATION								
To/From Level IV	34000	34000	14000	14000	14000	3000	3000	3000
GSE PRORATION	9267	9267	8167	8167	8167	5978	5978	5978
GRAND TOTAL	283212	293702	273266	280700	220174	277628	296185	230618

Table 2-16. Space Processing, Dedicated Pallet (Cost in 1977 $)

Cost Element \ Concept	A1	A2	B1	B4	C1	C4
MANPOWER						
Installation and Testing, Direct Labor (3,4,5,6,8,9)	23655	23750	23655	23750	23655	23750
Installation & Test Support (3 — 9)	—	—	2905	3150	5810	6300
Level III/II/I Integration Support (11,12,13)	17810	17810	17810	17810	17810	17810
Post Flight Support (15)	4745	4745	4745	4745	4745	4745
Deintegration Direct Labor (16)	2470	2470	2470	2470	2470	2470
TOTAL MANPOWER	48680	48775	51585	51925	54490	55075
TDY EXPENSE						
Installation & Test Direct Labor	2700	3768	5400	7537	10800	15075
Level III/II/I Integration Support	7050	7050	7050	7050	7050	7050
Post Flight Support	1800	1800	1800	1800	1800	1800
Deintegration Direct Labor	900	900	900	900	900	900
TOTAL TDY	12450	13518	15150	17287	20550	24825
TRANSPORTATION						
To/From Level IV	15000	15000	15000	15000	3500	3500
GSE PRORATION	4116	4116	4116	4116	2475	2475
TOTAL	80246	81409	85851	88328	81015	85875

Dedication Cost Analysis - Flight Hardware

In the baseline costing analysis, the cost contribution due to the Spacelab Flight Equipment (racks, pallets, floors, EPDB's, etc.) was calculated on a prorated basis. The equipment was laid out aginst a total ground processing time flow (from staging through integration, flight and deintegration) and the total days of involvement, together with the unit cost, were used to prorate the flight equipment cost on a per-mission basis. In the case of dedicated Spacelab equipment under the purchased equipment approach, a different rationale applies. In effect, the experiment Principal Investigator concerned "buys" the Spacelab equipment and has complete control of its use. It is not available for use on any other payload. Therefore he must pay the full value of the equipment whether he is flying it in the Orbiter or not. He must try to schedule a maximum number of flights for his payload or payload section to amortize the value of the equipment. The proper approach to costing in this case then is one of amortization, not proration. To determine the cost of the flight equipment per flight, the flight rate must then be considered. The total cost of the dedicated equipment listed in the "Dedication Break-Even Analysis - Purchase Equipment Approach" section is divided by the total number of flights anticipated in the program - calculated on a 10-year program - to get the cost amortized to one flight. For example, in the case of the Combined Astronomy payload with pallets 3 and 4 dedicated to the SIRTF, the flight equipment cost totals (6,305,000. For a total of 10 flights during the program (an average flight rate of 1 per year), the cost per flight would be $630,500. For 30 total flights, cost per flight would be $210,167. No flight rates beyond 4 per year (40 total) are included since the payload total processing time would not permit more than 4 per year for one set of Spacelab hardware. This variable cost per flight is added to the fixed cost per flight from other factors.

It is possible that a P.I. with a dedicated pallet, for example, may arrange and execute a flight rate for his payload which is above the break-even point (making dedication cost-effective) but below the saturation point of full utilization. In such a case, the pallet would have time available to support other payloads and it might be argued that this would require an adjustment in the amortized cost per flight. In principle, this is true, but several pitfalls appear. First, the cost and time required to deintegrate the dedicated payload, and reintegrate it, would cut appreciably into the remaining time available for supporting the "extra" payload flights. Secondly, the cost would have to be borne by the other experimenter since it would not be to the advantage of the dedicated P.I. This would make it less attractive than getting a stripped pallet directly from staging, if it is assumed that the extra P.I. would be paying the same prorated cost per day from either NASA-KSC staging or the dedicated P.I. Thirdly, the break-even points appear to be high enough that a large amount of unutilized time does not really exist, especially if the time required to deintegrate and reintegrate is subtracted. Fourthly, many of the advantages of dedication would be lost or reduced in such a "sub-lease" arrangement. In any case, the potential for this additional usage between the break-even point and the saturation point is highly speculative and impossible to determine so that an adjustment to the original cost amortization could be made.

Total Integration Cost Summary

Tables 2-11 through 2-16 present a Fixed Cost Analysis for all four study payloads for the six dedication candidates. The table is divided into Manpower, TDY, Transportation and GSE Proration cost sections. Manpower is subdivided into Level IV Integration, KSC Operations Support and Host Center Support. The Level IV Integration represents the actual "hands-on" manloading required for integration by P.I. personnel. KSC Operations Support represents manpower supplied by the P.I. to KSC during post-Level IV activities to provide advisory and overseeing support to the payload. Host Center support represents Lead Center or KSC personnel assisting PI personnel during the Level IV integration task. Those personnel away from their base of operations incur additional expenses under TDY costs, which are calculated under that heading. Transportation costs are based on the previously presented transportation guidelines, and cover transporting the payload itself, Spacelab hardware and GSE.

These tables reflect the reductions in manpower and processing time resulting from dedication, as calculated from the revised ground processing flow charts and GSE utilization charts. A degree of averaging and rounding is involved to permit the format to be followed as it was in the Baseline Cost Analysis tables. Transporation, however, was not found to be affected as far as cost is concerned. Unlike the Baseline Cost Analysis tables, flight hardware prorated cost is not included in the dedication cost tables, since it is a flight rate sensitive figure calculated in accordance with the paragraph entitled "Dedication Cost Analysis - Flight Equipment" and incorporated into the break-even charts data.

Break-Even Charts

Using the data presented in the Baseline and Dedicated cost analysis tables and the technique outlined in the paragraph entitled "Dedication Cost Analysis - Hardware" for the value of flight hardware in the dedicated buy case, a plot of Total Integration Cost vs. Total Flights was prepared for each dedication case. These are presented as Figures 2-16 through 2-21 herein. For simplification, the results of all "A" options, "B" options and "C" options were averaged to yield a single line for each basic option. The points at which the baseline and dedicated plots cross each other (so that the dedicated becomes less expensive than the baseline) is circled in each case. This point, the "break-even point" represents the number of flights in the total 10-year program which must be flown for that payload segment that would make the dedicated buy approach more cost effective than the baseline approach. Any number of flights beyond that point would result in saving additional amounts of money to the experimenter and the program, compared to the baseline approach.

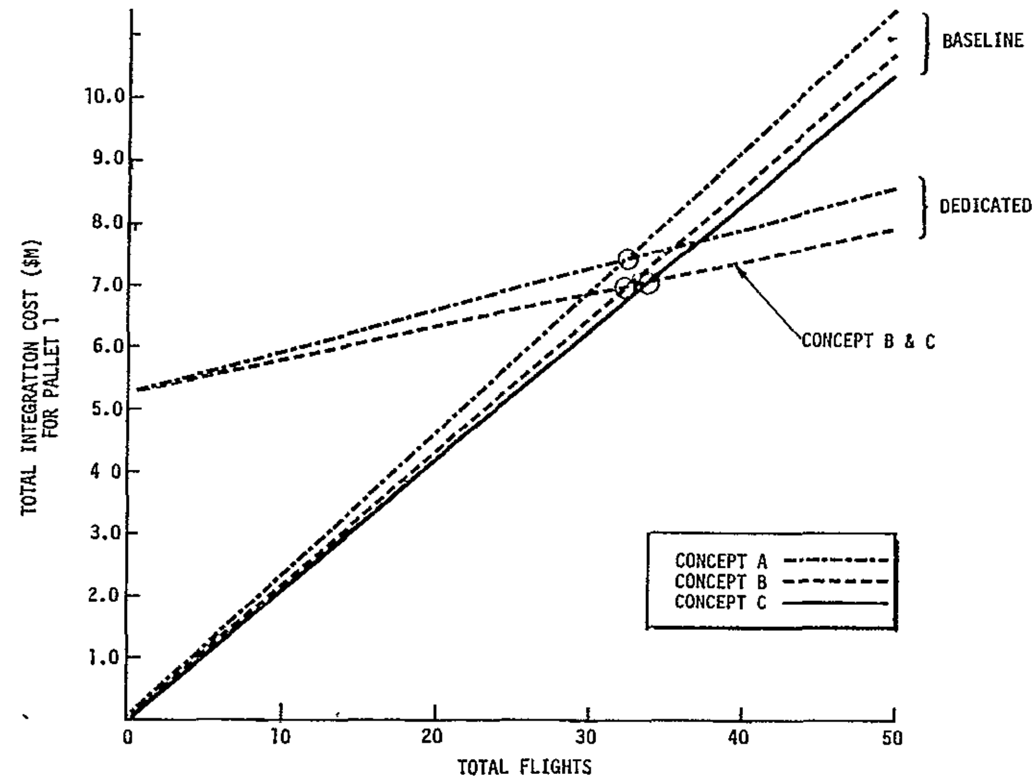

Figure 2-16. Dedicated Spacelab Equipment Combined Astronomy Dedicated Pallet 1

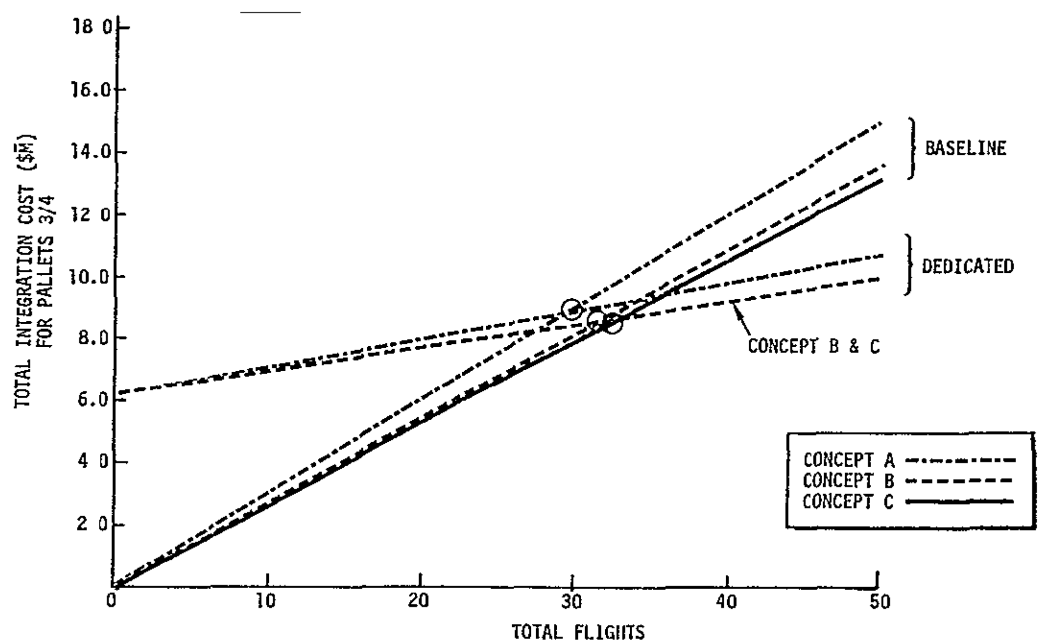

Figure 2-17. Dedicated Spacelab Equipment Combined Astronomy Dedicated Pallet 3/4

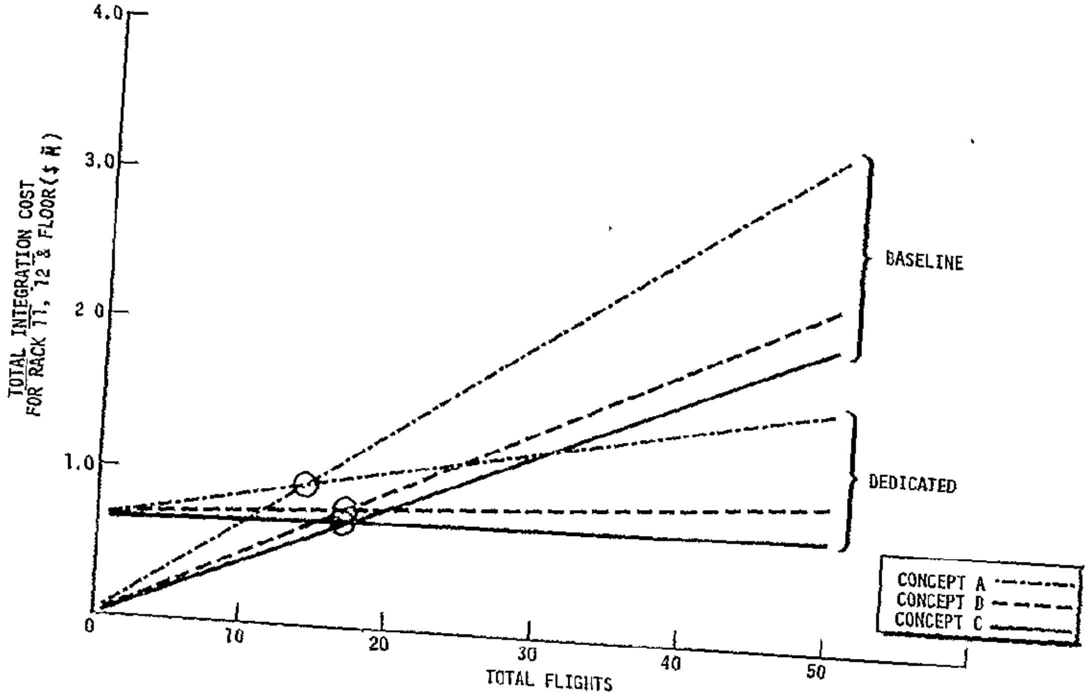

Figure 2-18. Dedicated Spacelab Equipment
Life Sciences - Dedicated Rack 11, 12 & Floor

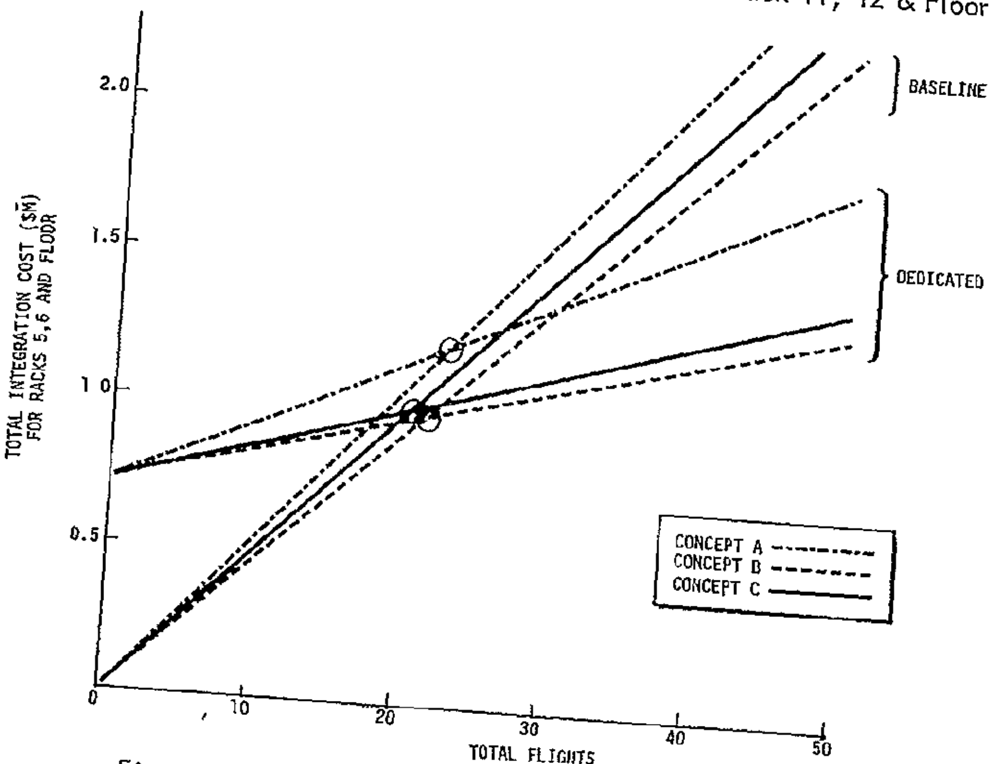

Figure 2-19. Dedicated Spacelab Equipment
ATL Dedicated Rack 5, 6, and Floor

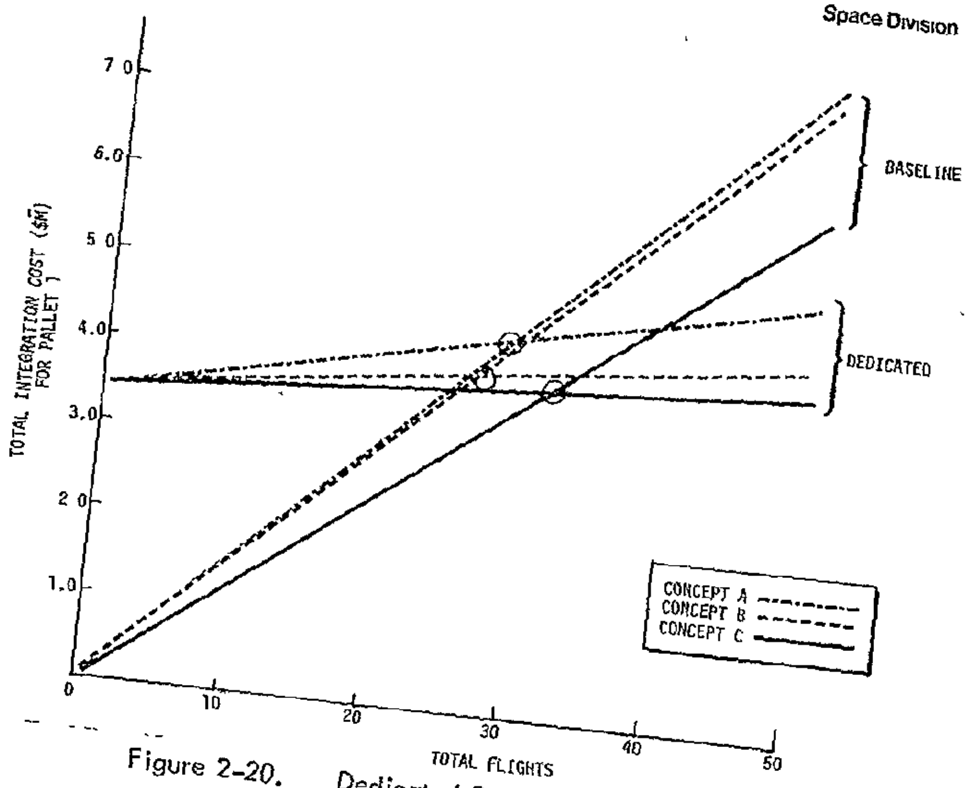

Figure 2-20. Dedicated Spacelab Equipment ATL Dedicated Pallet 1

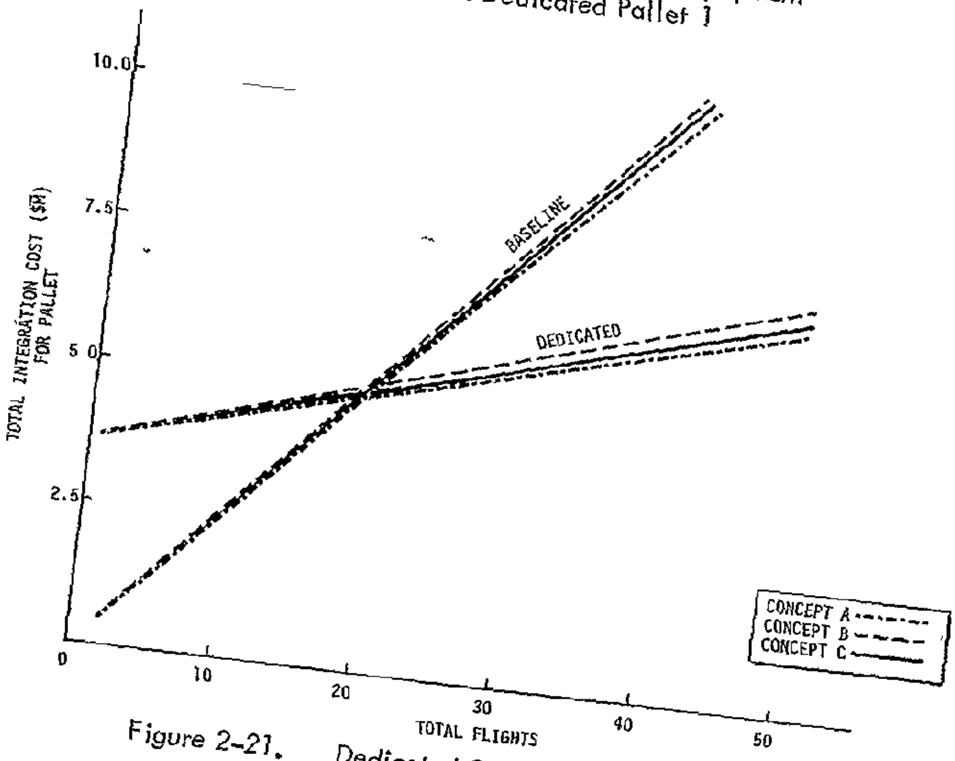

Figure 2-21. Dedicated Spacelab Equipment Space Processing-Dedicated Pallet

Dedication Cost Analysis - Leasing With Concentrated Flight Schedule

In this approach, the P.I. does not buy the Spacelab equipment, but leases it for a limited period of time. During this time period, he plans to fly all the missions needed for his project on a rapid turnaround basis, with no deintegration or reintegration required. Upon completion of the last flight of his project, the Spacelab equipment is returned to NASA for further utilization.

This approach concentrates, as did the previous approach, on the particular piece of Spacelab equipment being dedicated, rather than on the whole payload. It assumes that the other elements of the payload (other racks, pallets, etc.) are already fully installed and checked out on the experiment level before the dedicated item is available for integration. Therefore, the Level IV tasks included in the Total Ground Processing time include only (a) Receiving inspection of the pallet or rack, which has just returned from a flight, been deintegrated from the payload, and moved to the integration site, (b) installation of experiment equipment not dedicated to that pallet/rack, (c) experiment level verification, (d) payload inter-connection, payload checkout and disassembly for shipment, where these functional blocks apply. From this point on, the flow returns to the baseline flow except for an abbreviated deintegration operation as in the "dedicated buy" approach.

This approach results in the maximum reduction in involvement time for both flight equipment and GSE and is therefore lower than the baseline cost plan for any flight rate. However, it does require that the dedicated experiments must be flown very rapidly, without any time lapse between flights to assess data, make experiment modifications or adjustments of any magnitude. Many experiments cannot be performed effectively in this manner, especially where data must be sampled over a wide period of time or an iteration/evolution process is required, based on previous flights, to obtain meaningful experiment results.

Dedication Cost Analysis - Flight Equipment and GSE

To determine the prorated cost of Flight equipment and GSE in this approach, the baseline "waterfall" charts were re-reviewed and modified to reflect the deletion of pertinent installation steps and the assumption that other payload elements were already integrated and awaiting the dedicated element. This reduced integration time was then used as a basis for involvement time of both flight and GSE equipment. The equipment cost per flight was then calculated using the same prorating formula as in the baseline approach.

Dedication Cost Analysis - Manpower and TDY

Based on the deletion of installation tasks determined from review of the baseline "waterfall" charts, a reduction in the numbers of technicians and engineers and their involvement hours were applied to the baseline cost analysis sheets. The reductions were effective only in Blocks 3, 5 and 16 (when applicable), leaving all other blocks unaffected. The total manpower for each processing option was then recalculated. The TDY figures were also adjusted to reflect the reduced manpower levels and these totals recalculated.

Transportation was not affected by this dedication, and so no recalculation of this factor was required.

Total Integration Cost Summary

Since the actual comparison between the Concentrated Lease Dedication and the Baseline approach must consider only the costs associated with the dedicated Spacelab item, the total payload data derived as stated above had to be reduced to reflect only the costs associated with the dedicated item. Referring to the columns numbered in Table 2-17, this was done by examining the baseline manpower costs and apportioning a part of this cost to the dedicated segment of the payload (Column 1). Then, the total manpower for the payload in the baseline approach was compared to the total payload manpower in the dedicated case. This represents a delta cost (Column 2) totally attributable to the dedicated hardware. By subtracting this from the portion of the baseline manpower attributable to the dedicated hardware - Combined Astronomy Pallet 1 in the case of Table 2-17 - a figure for the manpower cost for the pallet in the dedicated case is obtained (Column 3). The same approach is followed for TDY costs (Column 4, 5 and 6).

Transportation costs shown (Column 7) are simply an assigned portion of the total payload transportation, and is unaffected by dedication.

In calculating GSE costs, the baseline GSE costs attributable to the dedicated hardware were determined by re-examination and abstraction from the total payload GSE requirements (Column 8). To determine the effect of dedication, the percent reduction in involvement time during Level IV activities was determined from the modified waterfall charts presented earlier (Column 9). Applying this percentage uniformly to the entire GSE complement cost resulted in a lower cost for the GSE in the dedicated case (Column 10).

Flight Hardware costs (Column 11) were calculated by prorating the actual dedicated hardware costs over the reduced involvement time represented in the dedicated flows.

The resultant cost summaries, and a comparison with baseline data for the dedicated hardware, are presented herein as Tables 2-17 through 2-22.

Cost Comparison Charts

In order to compare the costs of this dedication approach with the baseline costs of integrating the same hardware/experiments, the data in Tables 2-17 through 2-22 were plotted against baseline data. The plot of total integration cost (for the dedicated hardware only) against total flights of the project shows the amount of savings to be realized from this approach. Also, due to the reduction in total ground processing time in the dedicated case, the number of flights that can be made in a year is increased, and this is shown as well. These charts are presented herein as Figures 2-22 through 2-27.

Table 2-17. Dedicated Lease Cost Analysis - Combined Astronomy-Pallet 1 Dedicated ($K)

Option	P/L MP	-Ded. Δ	= Ded. MP	B/L TDY	- Ded Δ	= Ded TDY	Trans	B/L GSE	- % Red. in Inv. Time	= Ded. GSE	Flt Hdwe	Total	Avg. Ded.	Avg. B/L
A2	61.0	17	44	13	3	10	9	4.7	19.7	3.8	127	194	194	228
B2	61.0	16	45	11	3	8	4	3.5	18	2.9	132	192	179	215
B4	49.0	20	29	10	2	8	4	3.1	23.1	2.4	123	166		
C2	63.0	17	46	20	6	14	6	2.8	20	2.2	115	178	165	209
C4	51.0	20	31	17	3	14	6	2.4	30	1.7	106	153		

B/L = Baseline
MP = Manpower
DED = Dedicated
TDY = Temporary Duty
TRANS = Transportation
RED = Reduction
INV = Involvement
FLT = Flight
HDWE = Hardware

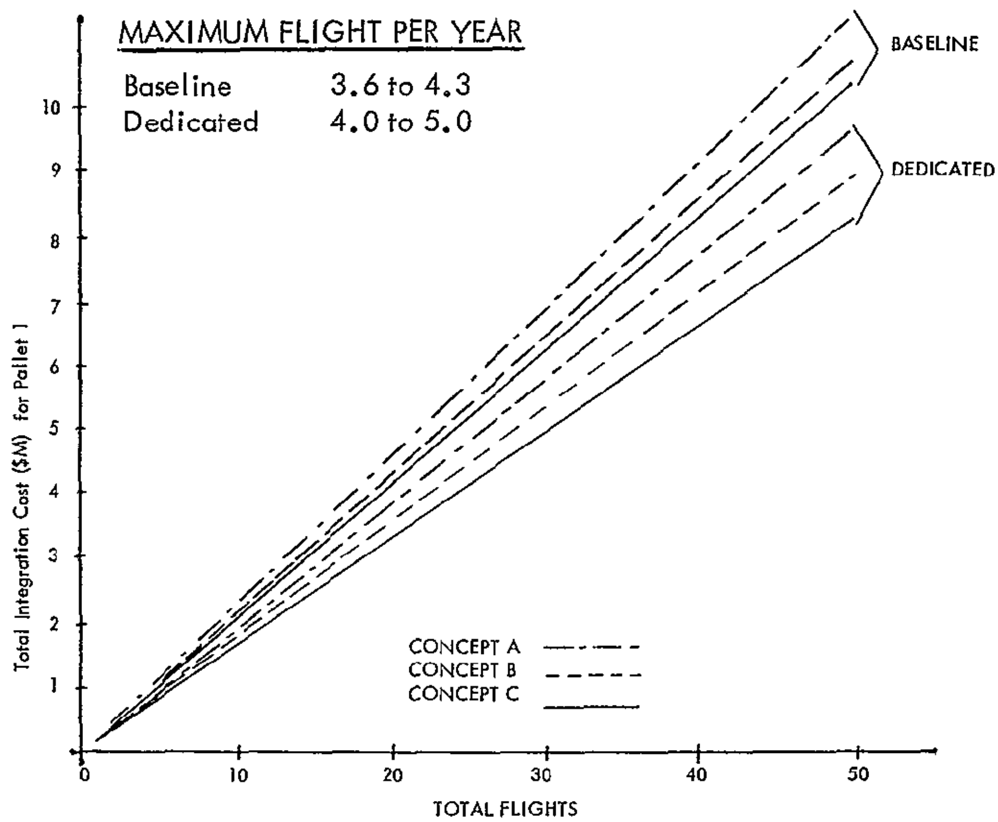

Figure 2-22. Dedicated Spacelab Equipment - Combined Astronomy Dedicated Leased Pallet 1

Table 2-18. Dedicated Lease Cost Analysis
Combined Astronomy-Pallet 3/4 Dedicated ($K)

Option	B/L MP	- Ded △	= Ded MP	B/L TDY	-Ded △	= Ded TDY	Trans	B/L GSE	-% Red. in Inv. Time	= Ded GSE	Flt Hdwr	Total Cost	Avg Ded.	Avg B/L
A2	88.9	23.1	65.8	7.9	0	7.9	17.8	6.4	16.7	5.3	165.2	262	262	298
B2	89.0	23.1	65.9	7.0	0	7.0	8.8	4.8	10.5	4.3	164.4	250	243	274
B4	74.0	16.3	57.7	13.5	2.2	11.3	8.8	4.2	15.1	3.6	153.6	235		
C2	92.6	21.7	70.9	23.1	5.2	17.9	1.2	3.8	13.3	3.3	144.3	238	227	265
C4	77.2	16.0	61.2	22.3	4.5	17.8	1.2	3.2	19.3	2.6	133.4	216		

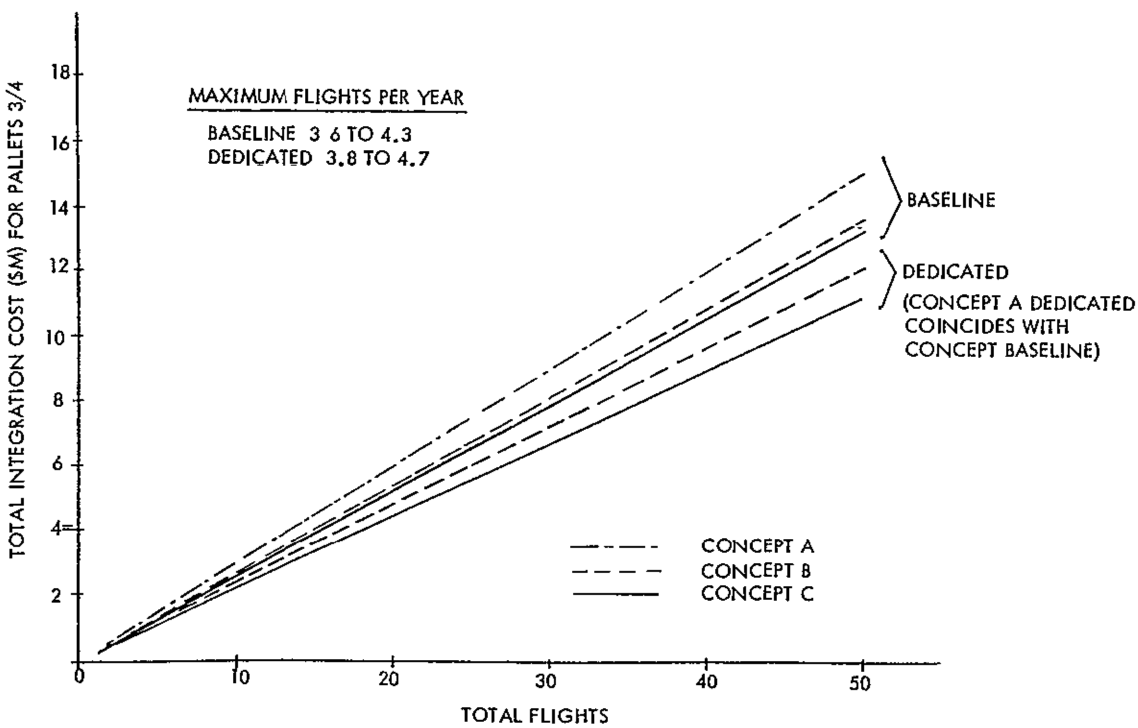

Figure 2-23. Dedicated Spacelab Equipment - Combined Astronomy-Dedicated Lease Pallet 3/4

Table 2-19. Dedicated Lease Cost Analysis
Life Sciences-Racks 11, 12 & Floor Dedicated ($K)

Option	B/L MP	- Ded Δ	= Ded MP	B/L TDY	- Ded Δ	= Ded TDY	Trans	B/L GSE	x % Red in Invlv. Time	= Ded GSE	Flt Hdwe	Total	Avg Ded.	Avg. B/L
A1	23.0	21.5	1.5	1.8	NC	1.8	17.0	3.7	32.7	2.5	15.1	38	41	66
A3	23.0	21.5	1.5	5.1	NC	5.1	17.0	3.7	25.8	2.7	17.3	44		
B1	20.5	6.7	13.8	1.8	0.6	1.2	3.6	1.1	36.3	0.7	15.1	34	36	46
B3	20.4	6.7	13.7	1.8	0.6	1.2	3.6	1.3	29.0	0.9	17.3	37		
B4	20.8	6.7	14.1	1.8	0.8	1.0	3.6	1.5	22.2	1.2	16.8	37		
C1	20.4	6.7	13.7	1.8	2.3	0	0.6	0.9	47.6	0.5	13.0	28	29	40
C3	19.4	6.7	12.7	1.8	2.3	0	0.6	1.2	35.8	0.8	15.2	29		
C4	20.8	6.7	14.1	1.8	2.3	0	0.6	1.3	27.8	0.9	14.7	30		

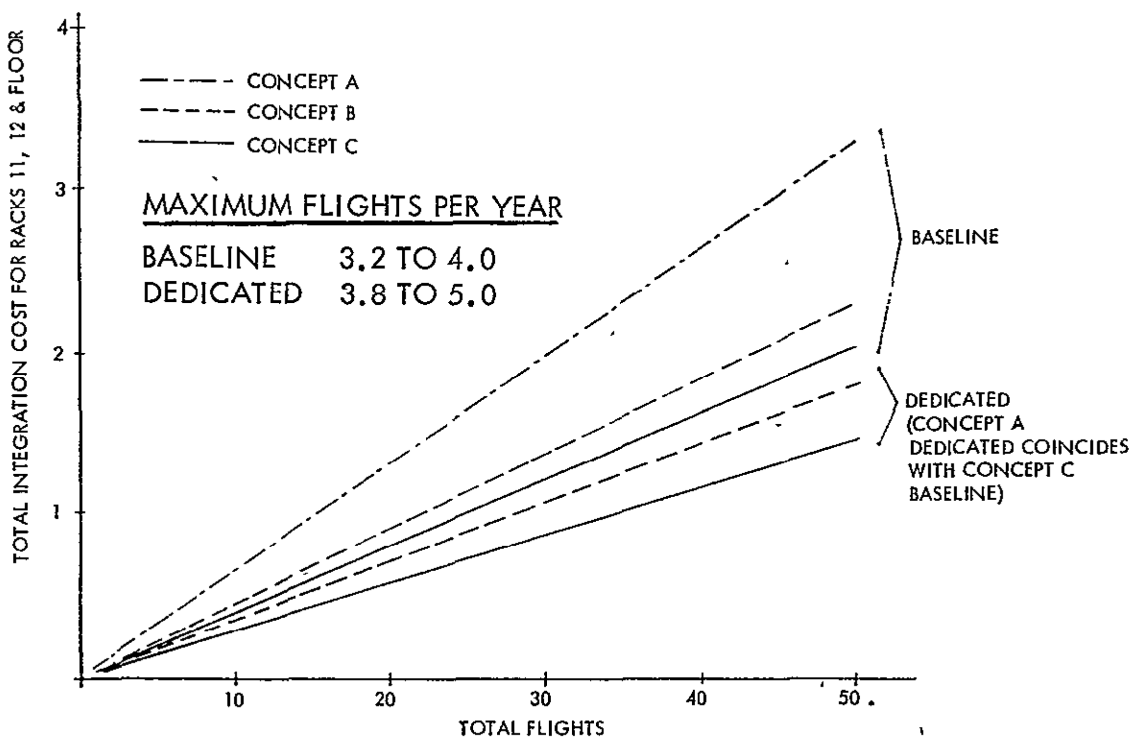

Figure 2-24. Dedicated Spacelab Equipment -
Life Sciences-Dedicated Lease Racks 11/12 & Floor

Table 2-20. Dedicated Lease Cost Analysis
ATL Rack 5, 6, & Floor Dedicated ($K)

Option	B/L MP	- Ded △	= Ded MP	- B/L TDY	- Ded △	= Ded TDY	Trans	B/L GSE	x % Red in Invlv. Time	= Ded GSE	Flt Hdwe	Total	Avg Ded.	Avg B/L
A1	19.8	16.2	3.6	2.0	1.0	1.0	8.5	1.9	32.9	1.3	16.9	31.3	33.2	53.2
A3	20.6	16.2	4.4	2.4	1.0	1.4	8.5	1.9	25.2	1.4	19.5	35.2		
B1	14.0	10.2	3.8	3.8	2.0	1.8	4.2	0.5	43.1	0.3	16.9	27.0	28.6	45.6
B3	14.8	10.2	4.6	6.2	1.9	4.3	4.2	0.5	35.0	0.3	19.3	32.7		
B4	14.6	12.5	2.1	3.0	1.6	1.4	4.2	0.5	33.0	0.3	17.9	25.9		
C1	14.0	10.2	3.8	7.6	3.8	3.8	0.9	0.4	55.0	0.2	14.6	23.3	24.3	48.5
C3	14.8	7.2	5.6	8.0	3.9	4.1	0.9	0.5	42.5	0.3	17.0	27.9		
C4	14.6	12.5	2.1	6.0	3.2	2.8	0.9	0.5	40.9	0.3	15.7	21.8		

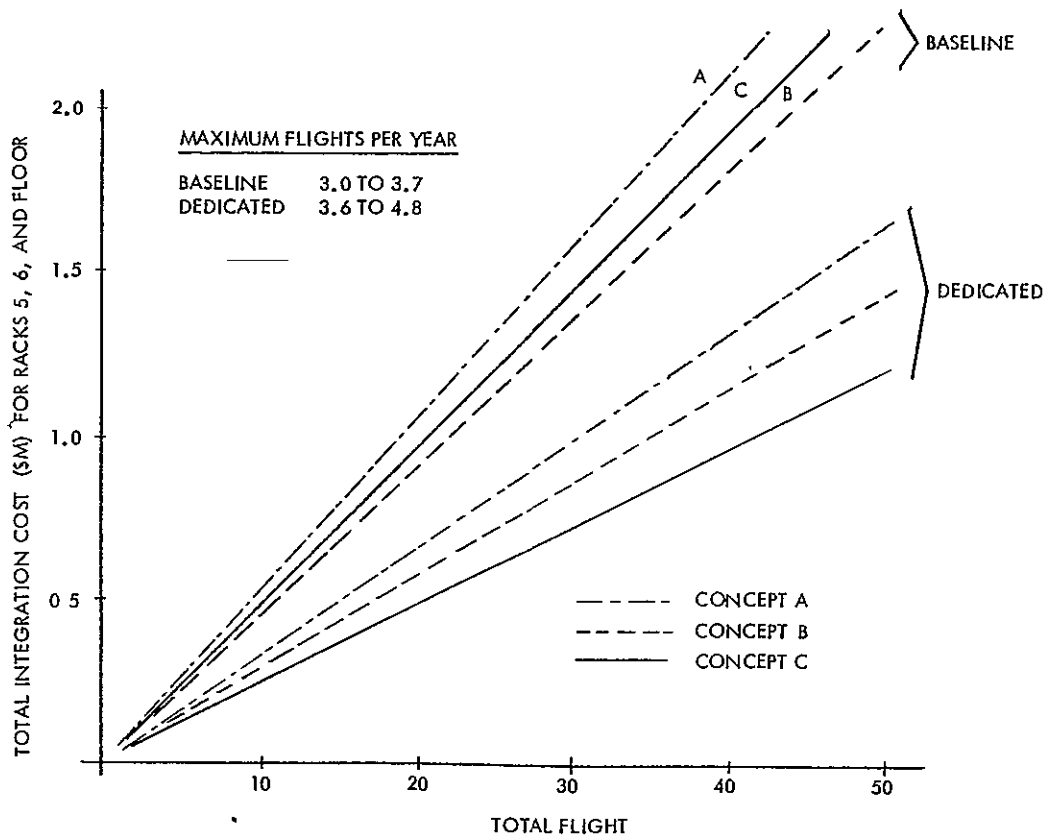

Figure 2-25. Dedicated Spacelab Equipment - ATL-Dedicated Lease Racks 5/6 & Floor

Table 2-21. Dedicated Lease Cost Analysis
ATL - Pallet 1 Dedicated ($K)

Option	B/L MP	- Ded Δ	= Ded MP	B/L TDY	- Ded Δ	= Ded TDY	Trans	B/L GSE	x % Red in Invlv Time	= Ded GSE	Flt Hdwr	Total	Avg Ded	Avg B/L
A1	39.5	11.4	28.1	2.0	0.7	1.3	8.5	3.4	22.7	2.6	123.3	164	174	195
A3	41.1	11.4	29.7	2.4	0.7	1.7	8.5	3.4	17.4	2.8	141.8	185		
B1	27.9	19.0	8.9	3.8	1.5	2.3	4.2	2.4	34.4	1.6	123.3	140	150	192
B3	29.5	19.0	10.5	6.2	1.5	4.7	4.2	2.8	28.0	2.0	139.8	161		
B4	29.1	17.1	12.0	3.0	2.2	0.8	4.2	2.8	27.0	2.0	129.3	148		
C1	27.9	19.0	8.9	7.6	4.5	3.1	4.2	1.9	43.9	1.1	107.7	125	131	167
C3	29.5	19.0	10.5	8.0	4.6	3.4	.7	2.2	33.9	1.5	124.2	140		
C4	29.1	17.1	12.0	6.0	4.5	1.5	.7	2.2	33.4	1.5	113.7	129		

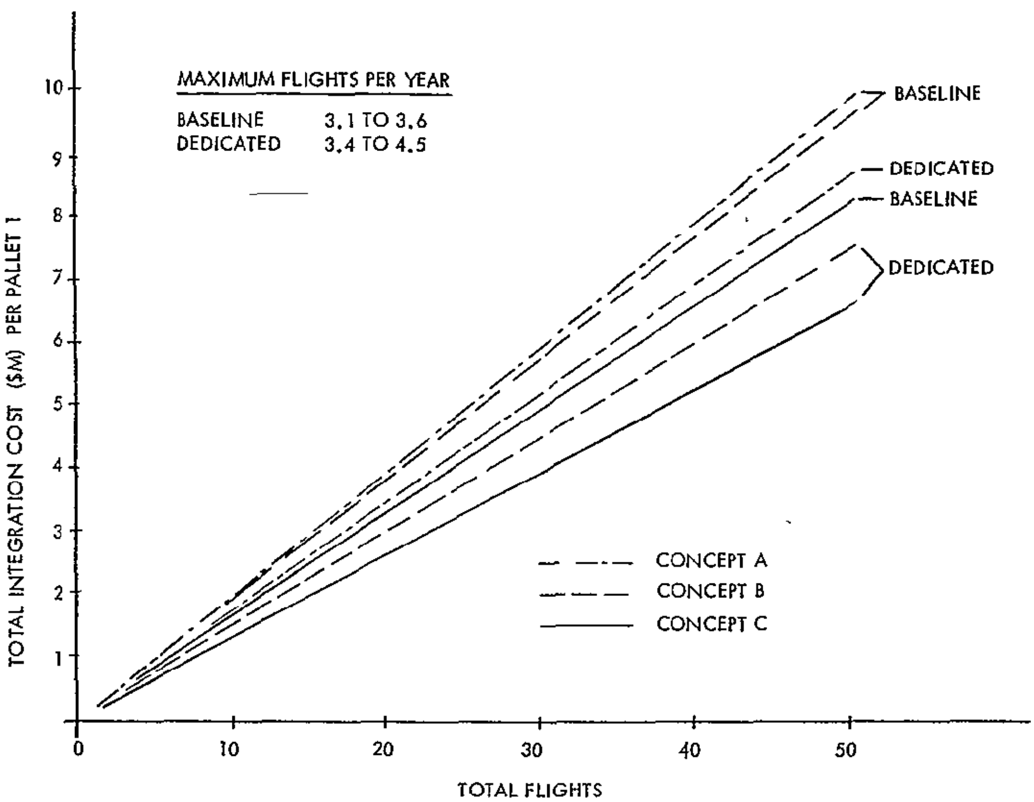

Figure 2-26. Dedicated Spacelab Equipment
ATL-Dedicated Lease Pallet 1

Table 2-22. Dedicated Lease Cost Analysis
Space Processing-Pallet Dedicated

OPTION	M/P	TDY	TRANS.	GSE	FLT HDWE	TOTAL DED	AVG DED	AVG B/L
A-1	48.7	12.5	1.50	4.1	80.0	160	160	266
A-2	48.8	13.5	15.0	4.1	80.0	161		
B-1	51.6	15.2	15.0	4.1	78.5	164	165	279
B-4	51.9	17.3	15.0	4.1	78.5	167		
C-1	54.5	20.6	3.5	2.5	66.6	148	150	275
C-4	55.1	23.8	3.5	2.5	66.6	152		

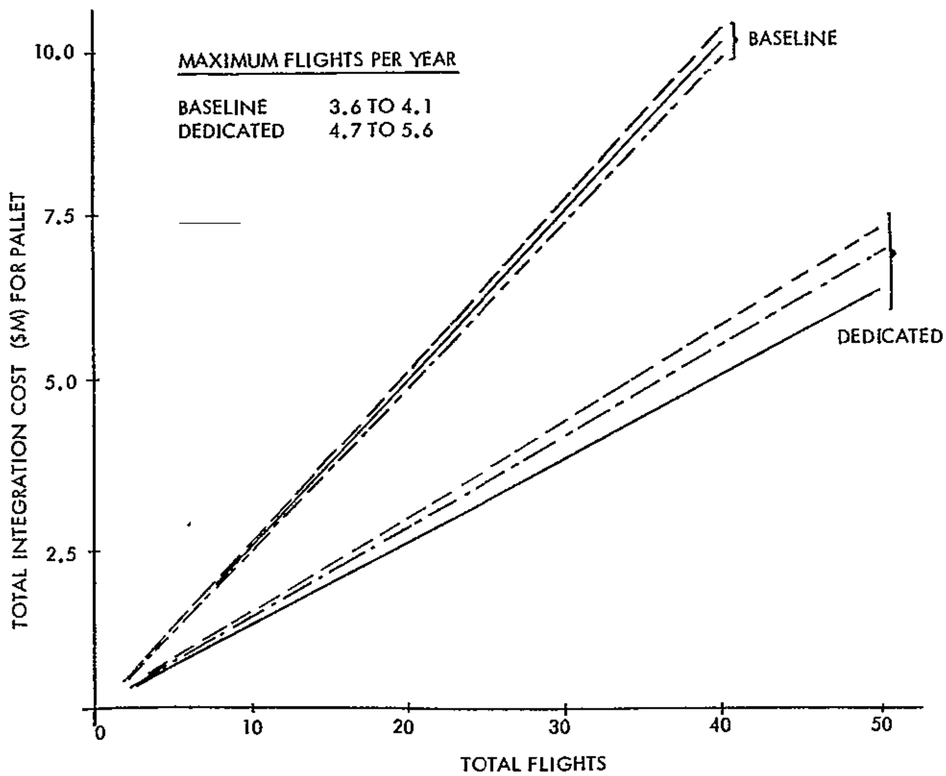

Figure 2-27. Dedicated Spacelab Equipment
Space Processing-Dedicated Lease Pallet

Dedication Analysis - Short Term Lease Approach

In this approach, as in the approach discussed in the preceding section (Dedication Analysis - Leasing With Concentrated Flight Schedule), the Principal Investigator leases rather than buys the Spacelab equipment into which he integrates his experiment hardware. However, in this case the lease is assumed to be for a period of one year. During that year, he can fly as few or as many times as he wishes, within the maximum limits imposed as a result of the involvement time required to integrate and process the payload. He may have a limited time between flights to analyze data from the previous flight. The analysis then addresses the question "what is the minimum number of flights required to make this approach more economical than the baseline approach?"

As with the previous approach, the analysis concentrates on the dedicated payload elements only (such as Combined Astronomy Pallet 1) and makes the assumption that the other payload elements are prepared off-line and are fully integrated at Level IV before the dedicated element is available. Therefore, the Level IV tasks are limited to (a) receiving inspection of the dedicated rack or pallet assembly and its experiment equipment, (b) installation of experiment equipment not dedicated to that pallet/rack, (c) experiment level verification, and (d) payload interconnection, checkout and disassembly for shipment where these functional blocks apply. From this point, as in the previous approach, the ground processing flow returns to the baseline flow except for the abbreviated deintegration operation.

Although the concept presented above is for a limited lease of one year, it can be extended to longer lease periods. This would result in increased savings over the baseline approach. Unlike the previous approach, some time is allowed between launches for data reduction, equipment modification and other purposes. Like the previous approach, a minimum flight rate is required to make the approach cost effective, so that experiments which require sampling or testing over a long period of time may not be feasible.

Dedication Cost Analysis - Manpower and TDY

Since the ground processing flow is based on the same dedication elements as in the previous approaches, and since the same assumption is made with regard to other payload elements already being integrated before availability of the dedicated element, as with the "Concentrated Lease" approach described above, the same manpower and TDY figures as used in that section will apply in this approach. No change in the number of manhours saved by dedication, nor the resultant TDY costs, results from this variation in the ground processing scenario.

Dedication Cost Analysis - GSE and Transportation

The GSE costs associated with integration, as in the case of the baseline resource requirements, are based on prorating the unit costs of the equipment over the involvement days of usage for each processing option. In the case of the Short Term Lease, the involvement times are the same as they were for the Concentrated Lease and so the GSE

costs per flight are also the same. Hence the figures used in the Concentrated Lease section are still applicable and are used in this approach as well. The baseline transportation costs are not changed by this or any other dedication approach; hence the baseline costs attributable to the dedicated payload element are again used in costing this dedication approach.

Dedication Cost Analysis - Flight Equipment

The cost of the Spacelab Flight Equipment per flight in this approach is calculated on a per-flight basis, for the dedicated elements only. The total equipment cost figures used are those presented in the "Dedication Break-Even Analysis-Purchased Equipment Approach" and have been used throughout all three dedication approaches.

In this approach, since the Short Term Lease is based on a one year period, an "annual cost" is calculated as 1/10 of the total equipment cost (based on a 10 year program plan). To express this in cost per flight, this figure was then divided by the number of flights to be carried out during the year, up to the limit imposed by the involvement time required per flight. For example, if the total involvement time per flight for a given payload (from staging, through all integration levels, flight mission, deintegration and back to staging) were 50 working days, this would permit a maximum flight rate in a 250-working-day year of 5 flights. If the dedicated equipment costs $5 million, this would yield an annual cost of $5 million divided by 10 years or $500,000, and a per-flight cost, for 5 flights in the year, of $100,000. The P.I. would be charged a lease fee of $500,000 for the year, and he could fly his experiments up to 5 times during the year, or less if he so wished.

Total Integration Cost Summary

The five integration cost factors discussed above (Manpower, TDY, Transportation, GSE and Flight Hardware) are summarized in Tables 2-23 through 2-28 following. Both baseline and dedicated data are shown, since the comparison must be made between these alternatives. Baseline cost-per-flight data were derived, as in the previous dedication approaches, from the total baseline costs. For Manpower and TDY, the totals were apportioned to represent only that part of the totals applicable to the dedicated elements. The transportation and GSE costs were apportioned by application of simple percentage factors. Flight hardware cost is based on the baseline proration formula applied to the cost of the specific dedicated flight hardware element. The total of these factors is shown as Baseline Cost/Flight in these tables.

Baseline Involvement time is based on the total ground processing and flight mission times as represented in Volume II "Total Life Cycle Flow" charts. The "Max. Flights" are calculated from these times as explained in the "Dedicated Cost Analysis-Flight Equipment" section, in both the baseline and dedicated cases.

Cost Comparison Charts

The data presented in Tables 2-23 through 2-28 for the six dedication cases is displayed graphically in Figures 2-28 through 2-33, comparing the baseline and dedicated cost totals as a function of flight rate for the year-long lease.

The baseline cost is, of course, a constant per-flight cost for each option. The options are averaged to yield a combined "A", "B", and "C" curves as was done previously. To get the per-flight cost in the dedicated case, the fixed cost subtotal (averaged for the letter option) was added to the flight hardware cost for each flight rate point, and the total plotted. The maximum flight rates are shown as "barriers" at the end of each solid plot line, and the intercepts of the baseline and dedicated plots are marked with small circles. These represent the flight rate at which the total integration cost FOR THE DEDICATED ELEMENT OF THE PAYLOAD is the same whether dedicated or undedicated, and can be considered a "break even" point beyond which the dedicated approach is the most cost effective.

Since, in most cases, the break even point occurs at a non-integer flight rate (which is impossible in a one year span), cost savings per flight and total are shown for the next integral flight rate. In some cases this requires extrapolation of the curve beyond the maximum flight rate barrier. This is not truly a fallacy since such scheduling devices as using 16-hour work days instead of 8-hour days could shorten the involvement time making such a flight rate possible.

Conclusions and Recommendations

In exploring and analyzing the various ways in which Spacelab flight equipment might be dedicated, it has been seen that dedication is feasible and cost effective in many, but not all, cases. Under any of the dedication approaches, a relatively frequent flight rate is necessary to justify dedication.

A comparison of the three basic dedication approaches would not be valid, since each approach has to be considered in the light of the planned flight schedule, project duration, and financial implications. For example, a university or research center planning to fly a series of astronomical flights with a SIRTF over a long period of time, at a flight rate of twice a year, would be best advised to use the purchase approach. An industrial user planning to manufacture semiconductor crystals in the Space Processing facility at a maximum capacity for a year, following which a major change in equipment would be necessary allowing a slower flight rate for the same production, would probably benefit from the short lease approach followed by a nondedicated lease arrangement. Hence a user considering dedication would first determine which dedication arrangement best fit his plans, and then determine if this arrangement would be cost effective at the flight rate he planned to follow.

A review of the conclusions that might be drawn from each approach would be beneficial in determining patterns leading to general guidelines for dedication.

Table 2-23. Short Lease Dedication Cost Analysis
Combined Astronomy-Pallet 1 Dedicated

Option	Dedicated Fixed Costs Per Flight					Baseline			
	Manpower	TDY	Trans.	GSE	Sub-total	Cost/Flt	Inv. Time	Max. Flts	Avg. Cost/Flt (Avg. Flt/Yr)
A2	44.0	10.0	9.0	3.8	66.8	228.0	62.3	4.0	228.0 (4.0)
B2	45.0	8.0	4.0	2.9	59.9	228.9	69.3	3.6	215.4 (3.7)
B4	29.0	8.0	4.0	2.4	43.4	201.9	66.3	3.8	
C2	46.0	14.0	0.6	2.2	62.8	221.4	61.3	4.1	208.9 (4.2)
C4	31.0	14.0	0.6	1.7	47.3	196.4	58.3	4.3	

Op- Flt. Rate	Annual Cost	Flight Hardware Cost/Flight						Dedicated		
		1	2	3	4	5	6	Invlvmt Time	Max. Flts.	Avg. Max. Flt/Yr
A2	530.9	530.9	265.4	177.0	132.7	106.2	—	59.8	4.2	4.2
B2		↓	↓	↓	↓	↓	↓	62.3	4.0	4.2
B4								58.0	4.3	
C2								54.3	4.6	4.8
C4								50.0	5.0	

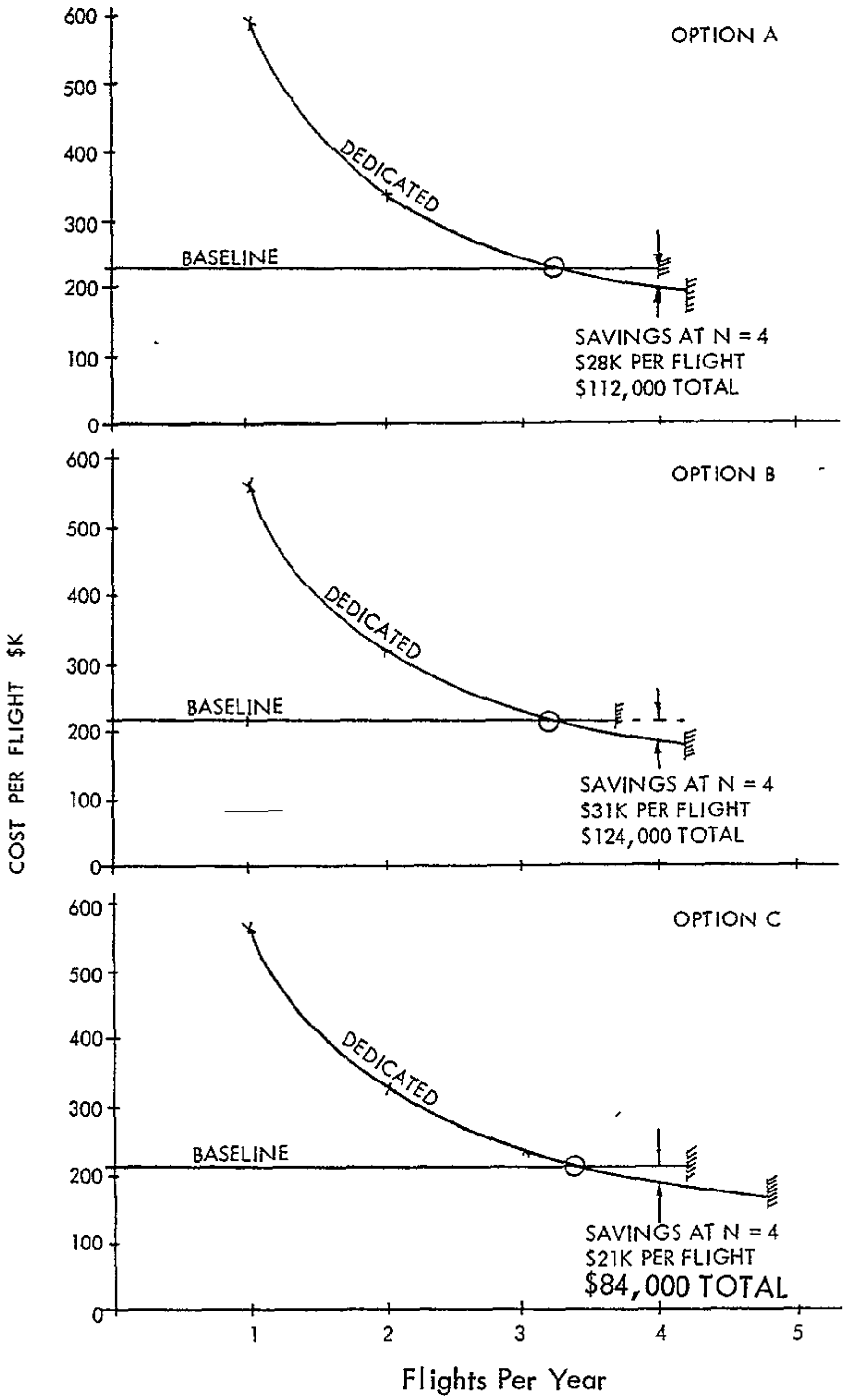

Figure 2-28. Short Lease Dedication
Combined Astronomy-Pallet 1 Dedicated

Table 2-24. Short Lease Dedication Cost Analysis
Combined Astronomy-Pallet 3/4 Dedicated

Baseline					Dedicated							
Option	Cost/Flt	Inv. Time	Max. Flts.	Avg Cost (Flts)	M/P	TDY	Trans.	GSE	Sub-Total	Involv. Time	Max. Flts/Yr	Avg Max Flts/Yr
A2	297.6	69.4	3.6	297.6 (3.6)	65.8	7.9	17.8	5.3	96.8	65.5	3.8	3.8
B2	286.1	69.3	3.6	273.9 (3.7)	65.9	7.0	8.8	4.3	86.0	65.2	3.8	4.0
B4	261.7	66.3	3.8		57.7	11.3	8.8	3.6	81.4	60.9	4.1	
C2	277.1	61.3	4.1	264.8 (4.2)	70.9	17.9	1.2	3.3	93.3	57.2	4.4	4.6
C4	252.6	58.3	4.3		61.2	17.8	1.2	2.6	82.8	52.9	4.7	

Dedicated						
Annual Cost	Flight Hardware Cost Per Flight					
	1	2	3	4	5	6
630.5	630.5	315.2	210.2	157.6	126.1	105.1

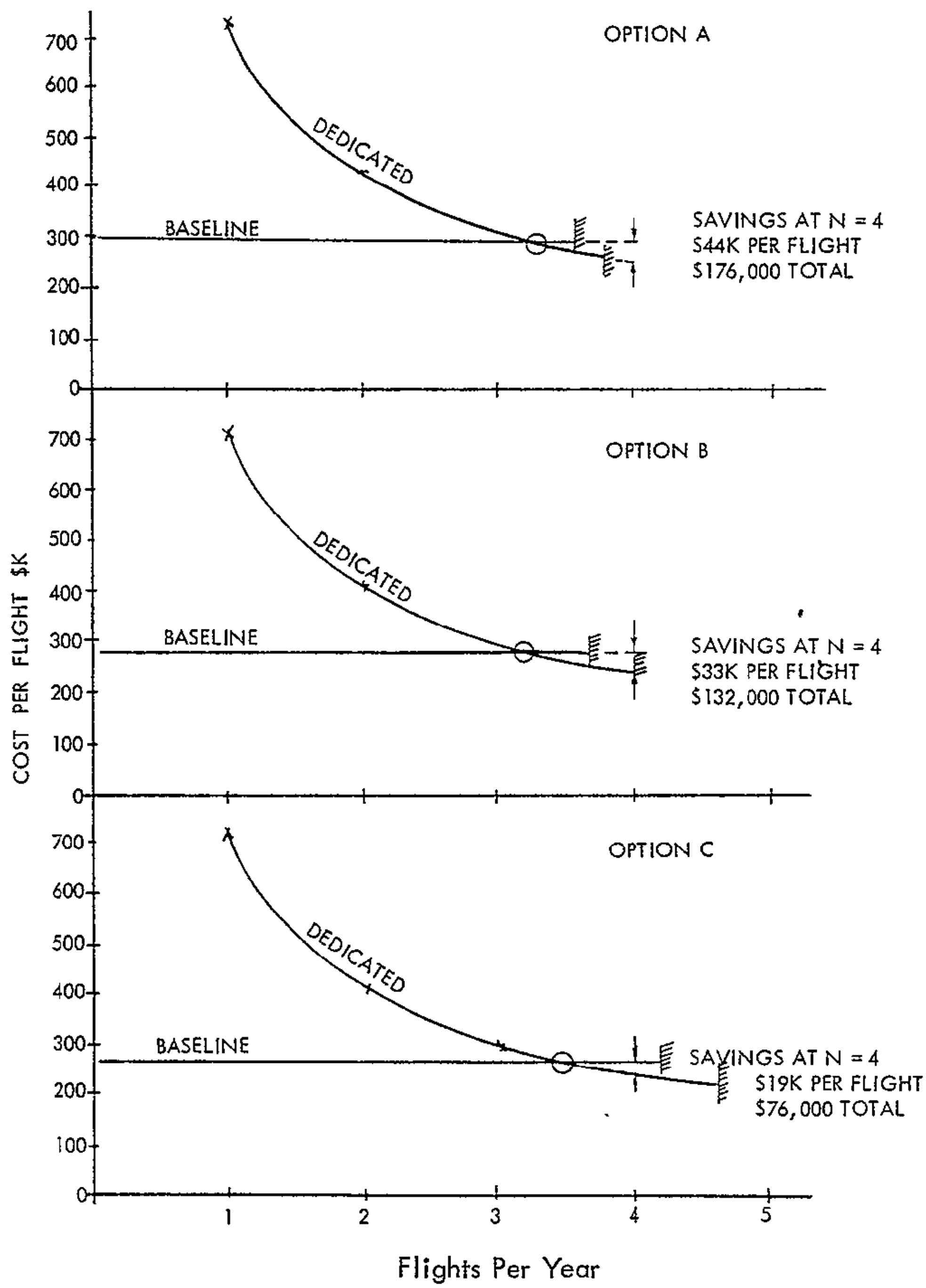

Figure 2-29. Short Lease Dedication - Combined Astronomy-Pallet 3/4 Dedicated

Table 2-25. Short Lease Dedication Cost Analysis
Life Sciences - Racks 11, 12 and Floor Dedicated

Baseline					Dedicated							
Option	Cost/Flt	Involv. Time	Max. Flts.	Avg Cost (Flts)	M/P	TDY	Trans	GSE	Sub-Total	Involv. Time	Max. Flts/Yr	Avg. Max Flts/Yr
A1	63.4	68.4	3.7	65.9 (3.5)	10.5	1.8	17.0	2.5	31.8	58.0	4.3	4.1
A3	68.4	76.9	3.3		10.5	1.8	17.0	2.7	32.0	66.5	3.8	
B1	44.6	70.2	3.6	45.9 (3.4)	13.8	1.2	3.6	0.7	19.3	58.0	4.3	4.0
B3	46.4	78.7	3.2		13.7	1.2	3.6	0.9	19.4	66.5	3.8	
B4	46.7	73.3	3.4		14.1	1.0	3.6	1.2	19.9	64.5	3.9	
C1	39.3	62.2	4.0	40.3 (3.8)	13.7	0	0.6	0.5	14.8	50.0	5.0	4.6
C3	40.2	70.7	3.5		12.7	0	0.6	0.8	14.1	58.5	4.3	
C4	41.5	65.3	3.8		14.1	0	0.6	0.9	15.6	56.5	4.4	

Dedicated						
Annual Cost	Flight Hardware Cost Per Flight					
	1	2	3	4	5	6
65.1	65.1	32.6	21.7	16.3	13.0	10.9

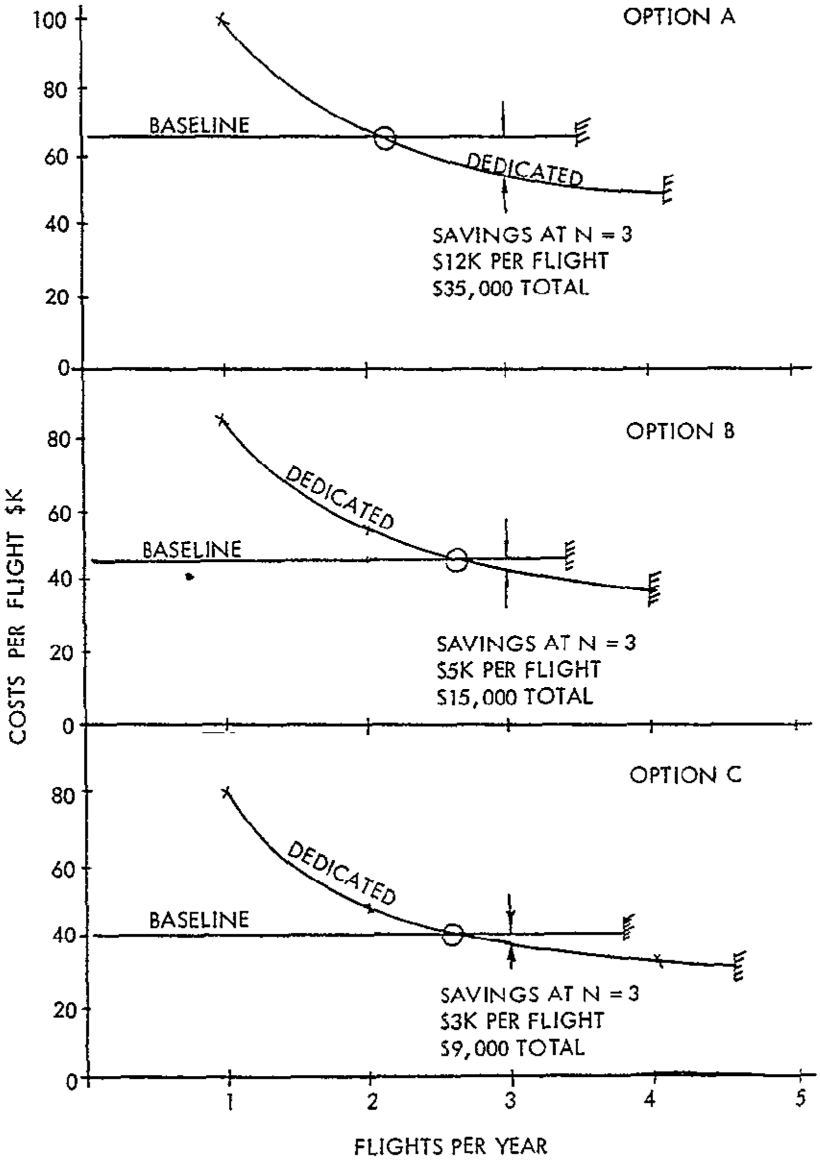

Figure 2-30. Short Lease Dedication - Life Science-Racks 11, 12, Floor-Dedicated.

Table 2-26. Short Lease Dedication Cost Analysis
ATL Racks 5, 6, and Floor Dedicated

Baseline					Dedicated							
Option	Cost/Flt	Involv. Time	Max. Flights	Avg. Cost (Flts)	M/P	TDY	Trans.	GSE	Sub-Total	Involv. Time	Max. Flts/Yr	Avg. Max Flts/Yr
A1	51.9	70.3	3.6	53 (3.4)	3.6	1.0	8.5	1.3	14.4	60.0	4.2	3.9
A3	54.5	79.8	3.1		4.4	1.4	8.5	1.4	15.7	69.5	3.6	
B1	43.8	75.9	3.3	46 (3.2)	3.8	1.8	4.2	0.3	10.1	60.0	4.2	3.9
B3	48.2	84.4	3.0		4.6	4.3	4.2	0.3	13.4	68.5	3.6	
B4	44.8	77.5	3.2		2.1	1.4	4.2	0.3	8.0	63.8	3.9	
C1	47.6	67.9	3.7	48 (3.5)	3.8	3.8	0.9	0.2	8.7	52.0	4.8	4.5
C3	50.0	76.4	3.3		5.6	4.1	0.9	0.3	10.9	60.5	4.1	
C4	47.8	69.5	3.6		2.1	2.8	0.9	0.3	6.1	55.8	4.5	

Dedicated						
Annual Cost	Flight Hardware Cost Per Flight					
	1	2	3	4	5	6
70.3	70.3	35.2	23.4	17.6	14.1	11.7

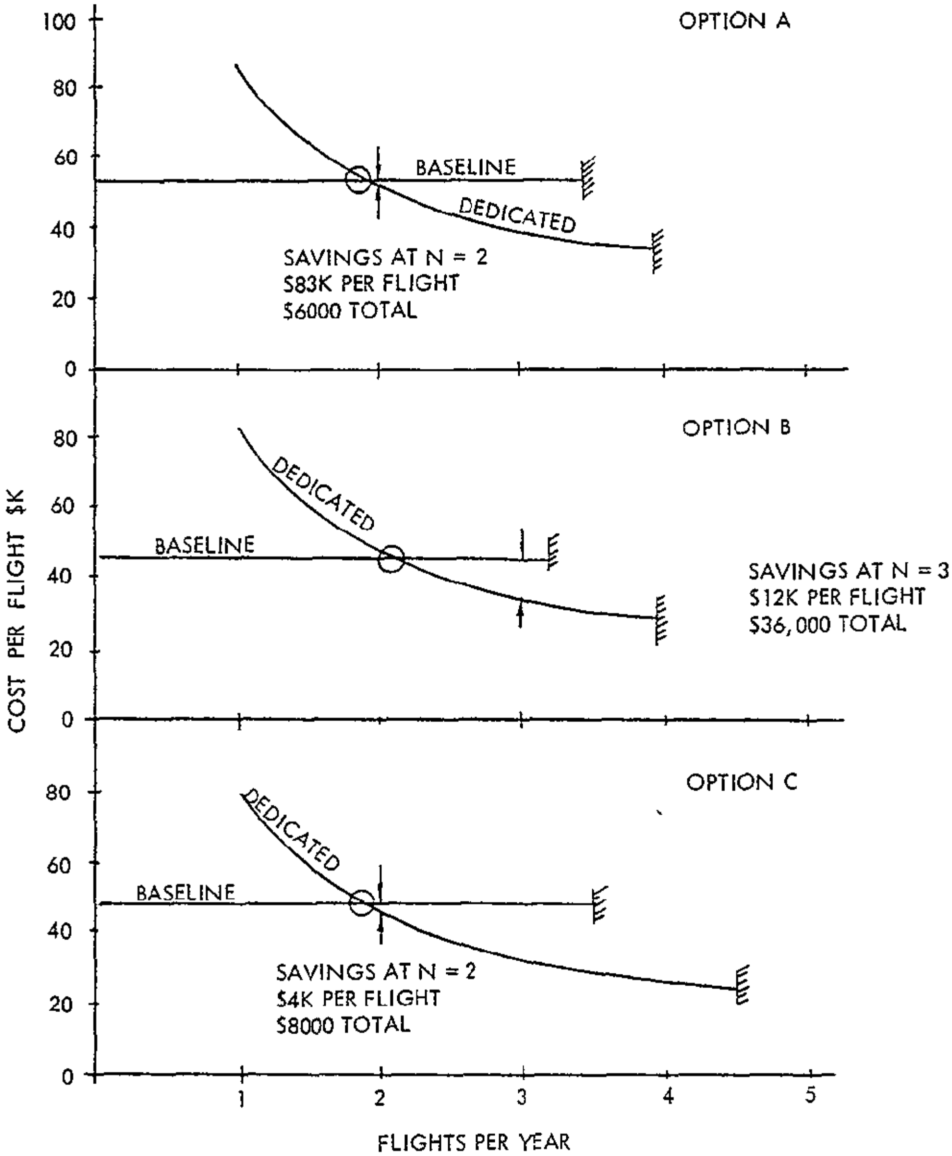

Figure 2-31. Short Lease Dedication - ATL-Racks 5, 6, Floor-Dedicated

Table 2-27. Short Lease Dedication Cost Analysis
ATL - Pallet 1 Dedicated

Baseline					Dedicated							
Option	Cost/Flt	Involv. Time	Max. Flts.	Avg. Cost (Flts)	M/P	TDY	Trans.	GSE	Sub-Total	Involv. Time	Max. Flts/Yr	Avg. Max Flts/Yr
A1	190.0	70.3	3.6	195.9 (3.4)	28.1	1.3	8.5	2.6	40.5	63.2	4.0	3.7
A3	201.7	79.8	3.1		29.7	1.7	8.5	2.8	42.7	72.7	3.4	
B1	186.6	75.9	3.3	191.9 (3.2)	8.9	2.3	4.2	1.6	17.0	63.2	4.0	3.8
B3	198.8	84.4	3.0		10.5	4.7	4.2	2.0	21.4	71.7	3.5	
B4	190.2	77.5	3.2		12.0	0.8	4.2	2.0	19.0	66.3	3.8	
C1	163.2	67.9	3.7	167.0 (3.5)	8.9	3.1	0.7	1.1	13.8	55.2	4.5	4.2
C3	172.4	76.4	3.3		10.5	3.4	0.7	1.5	16.1	63.7	3.9	
C4	165.6	69.5	3.6		12.0	1.5	0.7	1.5	15.7	58.3	4.3	

Dedicated						
Annual Cost	Flight Hardware Cost Per Flight					
	1	2	3	4	5	6
487.6	487.6	243.8	162.5	121.9	97.5	81.3

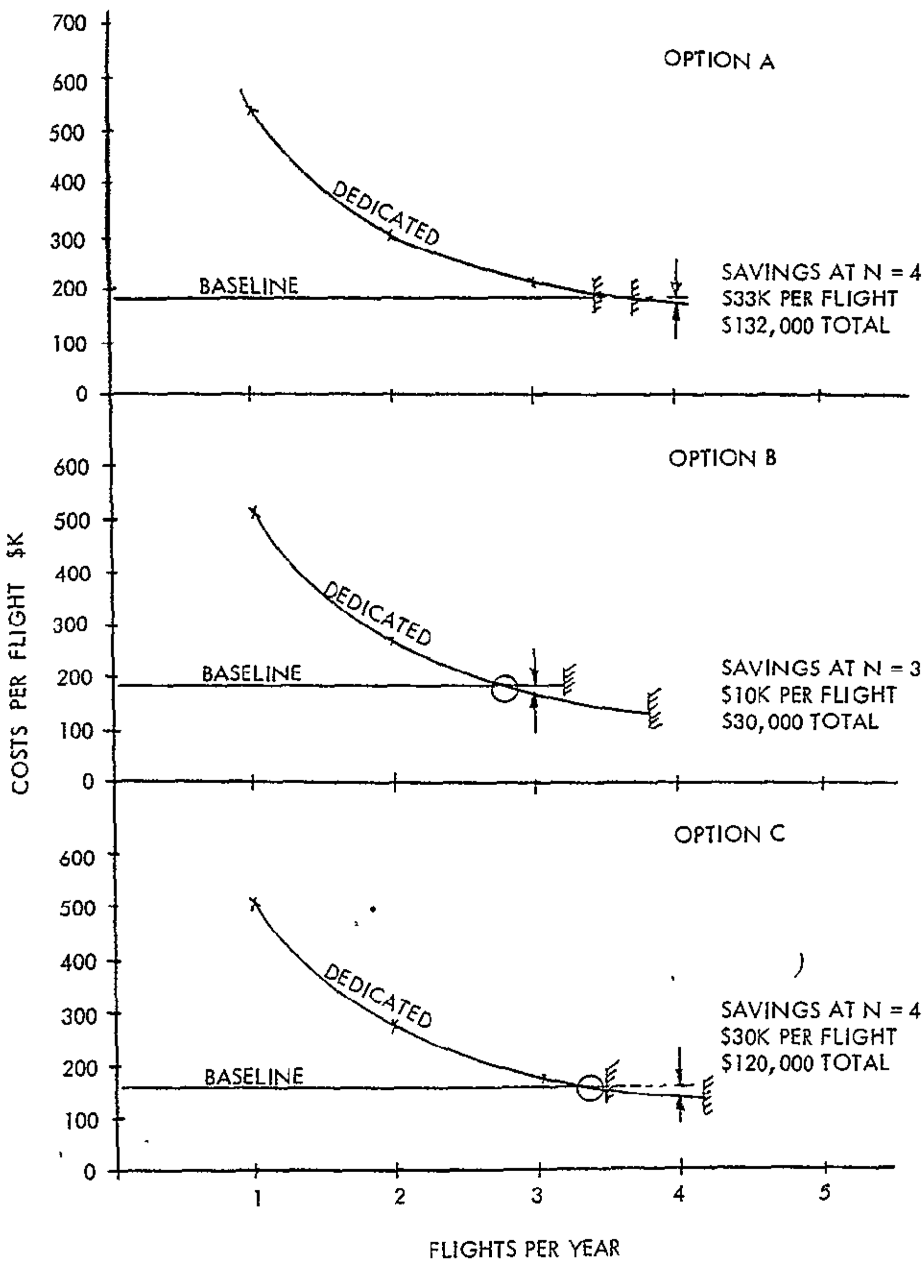

Figure 2-32. Short Lease Dedication - ATL-Pallet 1-Dedicated

Table 2-28. Short Lease Dedication Cost Analysis
Space Processing - Pallet Dedicated

Baseline					Dedicated							
Option	Cost/Flt	Involv. Time	Max. Flts	Avg. Cost (Flts)	M/P	TDY	Trans.	GSE	Sub-Total	Involv. Time	Max. Flts/Yr	Avg. Max Flts/Yr
A2	268.3	69.1	3.6	268.3 (3.6)	35.7	4.8	15.0	4.1	59.6	53.7	4.7	4.7
B2/B4	281.4	68.1	3.7	281.4 (3.7)	38.5	9.5	15.0	4.1	67.1	52.7	4.7	4.7
C2/C4	277.1	60.1	4.2	277.1 (4.2)	41.3	14.2	3.5	2.5	61.5	44.7	5.6	5.6

Dedicated						
Annual Cost	Flight Hardware Cost Per Flight					
	1	2	3	4	5	6
372.4	372.4	186.2	124.1	93.1	74.5	62.1

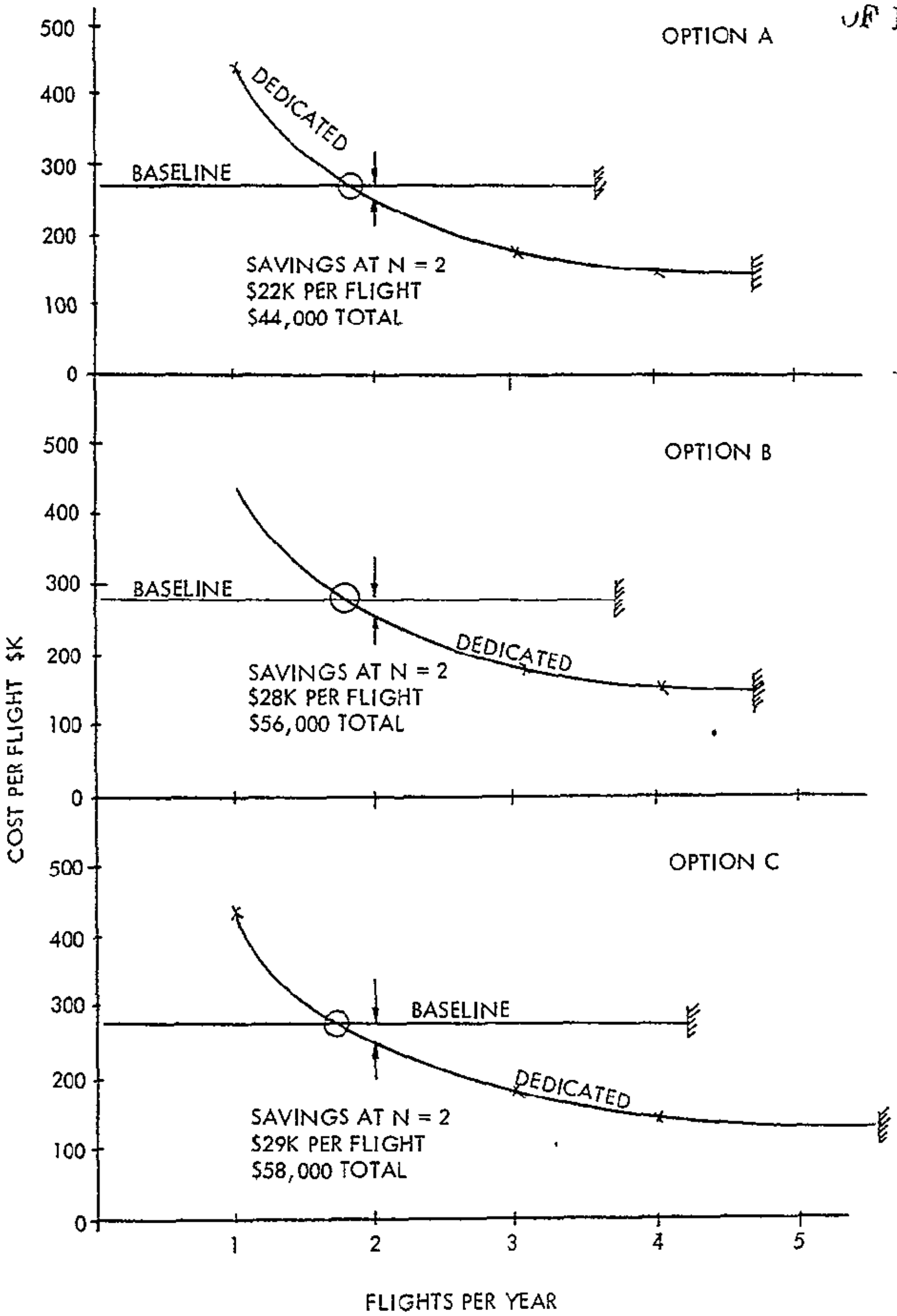

Figure 2-33. Short Lease Duration - Space Processing-Pallet Dedicated

Dedicated Buy Approach

Reviewing the break-even charts and the calculations in this approach, several conclusions can be drawn. First, the effects of dedication are approximately the same regardless of whether Concepts A, B or C are being followed. Secondly, it can be seen that a rather extensive flight schedule is required for the savings from dedication to offset the capital investment cost. This is particularly true for pallet payloads which involve much more expensive flight equipment. The pallet payloads require on the order of 30 flights (except Space Processing) to pay off - the equivalent of 3 flights per year for the entire program. Space Processing takes less time because of very high cost savings realized from dedication. Rack payloads, on the other hand, require only 15 to 20 flights to pay off and are therefore better candidates for this form of dedication.

Dedicated Lease with Concentrated Flight Schedule

In this approach, a review of the cost comparison charts reveals that a savings can be realized in all cases, regardless of flight rate, but of course since a concentrated launch schedule is presupposed, this approach is inapplicable unless multiple flights on a tight schedule are planned. The savings are less than dramatic (except for Space Processing as explained above) until a large number of flights are reached. In this approach, the difference between pallet payloads and rack payloads is must less apparent, because the flight hardware cost becomes less of a factor when it is based on proration rather than amortization.

Dedicated Short Term Lease

The data for this approach, where full utilization is not presupposed as it was in the Dedicated Lease with Concentrated Flights Schedule, involves a break-even situation again as we saw in the dedicated buy approach. The savings from dedication are weighed against the cost of underutilized hardware, and at a certain flight rate for the one year lease period, savings may be realized. The most significant conclusion evident from these break-even charts is that, as with the dedicated buy approach, rack payloads exhibit quicker and more dramatic savings than do pallet payloads. This, again, is due to the predominant effect of flight hardware cost in an underutilization situation as we see here. Again, Space Processing proves itself to be an exception because of the very significant integration/deintegration savings and somewhat lower pallet costs from the other pallet payloads. With the exception of Space Processing, pallet payloads appear to exhibit cost savings at 80 to 90% utilization while rack payloads exhibit savings at only 50 or 60% utilization.

SHARED SPACELAB EQUIPMENT UTILIZATION

General

The objectives of this sub-task were to determine costs and schedule implications of shared Spacelab equipment utilization through progressive Level IV integration of shared Spacelab hardware. This shared hardware included Spacelab unique equipment such as racks, pallet segments, RAU's, and common support equipment (recorders, IPS, telescopes, chambers, etc.) and GSE.

"Shared Level IV checkout flows" were developed and compared against baseline Level IV checkout flows to form the basis for analyzing manpower requirements, cost data and use (involvement) times for selected GSE. (A "shared checkout flow" is one which moves the equipment and personnel from one principal investigator's facility to another in the Level IV shared buildup, assembly and checkout of payload equipment for specific missions.) Shared flows were developed for four payloads, namely (1) Advanced Technology Laboratory, (2) Combined Astronomy, (3) Space Processing, and (4) Life Sciences.

It was not anticipated that this evaluation would prove that shared integration would be cost effective. GSE inventory and TDY requirements would probably decrease but the increase in flight hardware involvement time and transportation costs will significantly increase. Therefore, the significance of the data from the shared Spacelab hardware analyses is to provide cost estimates that can be considered for those experiment/payload cases that may not be integrated at a single Level IV integration site. That is, experiment unique test equipment, test facilities, and/or safety constraints may preclude transportation to an integration site. Environmental proof testing may be required at multiple sites for some payloads. The data from the shared hardware analyses can be of help in assessing the cost implications of the ground processing of these unique payloads.

Certain assumptions were made for purposes of this analysis. These assumptions are listed below and apply for all cases involved in this evaluation.

a) All Spacelab Equipment will be staged (stored, refurbished) at KSC

b) GSE and Spacelab Equipment moves with the payload

c) GSE and Spacelab Equipment moves progressively to each Principal Investigator's Site

d) The involvement time for GSE is based on a dedication rule, that is, once the equipment has been selected for use, even on an intermittent basis, for a particular mission, it will be dedicated to that task for the entire mission period.

Advanced Technology Laboratory (ATL)

The ATL payload consists of Pallet 1, Pallet 2, Rack 3a, 3b, 4a, 4b, 5 and 6 and a Forward Structure. For purposes of this study, the equipment was subdivided into three groups designated Mini-Center 1, 2 and 3. Mini Center 1 group of equipment consisted of the floor, Pallet 1, Rack 5 and 6. Mini Center 2 group of equipment consisted of Racks 3a and 3b. Mini Center 3 group of equipment consisted of Pallet 2, Racks 4a and 4b, and the forward structure. ATL Progressive Experiment/Facility Flow, Figure 2-34, presents a means of quickly identifying experiments, sites and hardware. For example, Pallet No. 1 has experiment ST25 end items 4 and 5 installed at Site No. 1 and experiment ST10 end items 1 thru 13 installed at Site No. 2 after which Pallet No. 1 is shipped to KSC.

The progressive flows for the ATL payload are presented in chart form. Figure 2-35 shows Mini-Center No. 1 shared flow which utilizes 260 hours compared to 128 for the baseline. Mini Center No. 2, shown in Figure 2-36, utilizes 112 hours for the progressive compared to 63 hours for the baseline. Mini Center No. 3, shown in Figure 2-37, indicated 538 hours are required for the shared compared to 152 hours for the baseline.

Combined Astronomy

The Combined Astronomy payload is presented in three checkout cases, 1, 2, and 3. Since this experiment contains three experiments, the equipment is subdivided such that Pallet No. 1, the forward most pallet in the Payload Bay, is at one Principle Investigator's (PI) Site while the mid pallets, No. 2, 3 and 4, are at Site No. 2 and Pallet No. 5, the aft pallet is processed at Site No. 3. Case No. 1 starts the initial Level IV activities at the same time for the forward, mid and aft experiments - each experiment being integrated at a different site. Case No. 2 starts the forward and mid experiment Level IV activity at the same time but delays the start of Level IV tasks for the aft experiment so that the same GSE can be used for both the mid and aft experiment. Case No. 3 adjusts the Level IV integration activities such that the forward, mid and aft experiments are checked out sequentially. This results in minimum GSE for Level IV integration activities.

Figure 2-38 presents a summary of the shared flows for the Combined Astronomy payload. Shared flows for the three cases were compared with the baseline flows. Case 1 initiates Level IV activity from a common timeline for the forward, mid and aft pallet complements. Only the forward complement was cycled from one site to another for experiment integration. Estimates indicated costs of $291,200 and 138 serial hours for this shared case as compared to $89,120 and 58 serial hours for the baseline. Case 1 utilized three sets of GSE. Case II initiates forward and aft pallet Level IV activities at the same time. The mid pallet complement Level IV activity was scheduled such that the aft pallet Level IV GSE equipment could be used for the mid pallet complement integration activities. The flow times are about the same as Case 1. In Case III, the forward, mid and aft pallet activities were scheduled such that only one set of checkout and servicing GSE was required. However, the involvement times for the flow increased to 501 serial hours.

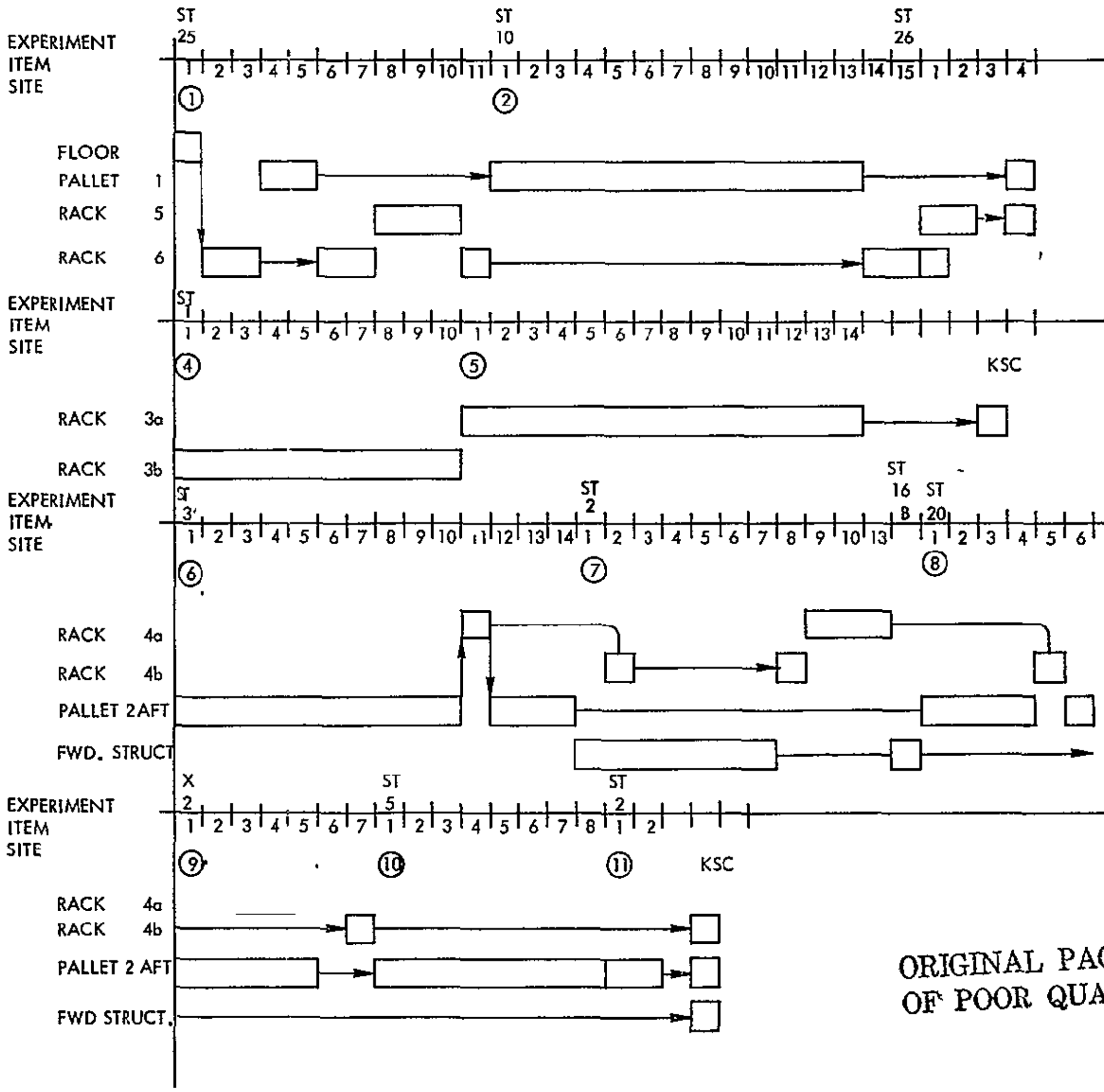

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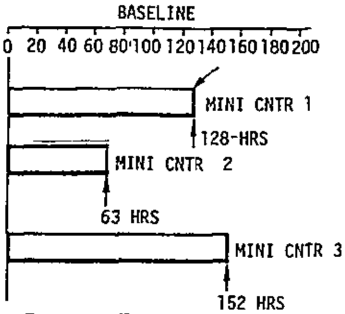
Figure 2-34. ATL Shared Experiment/Facility Flow



MINI CENTER	SITE	EXP	EQPT
1	1	25	FLOOR
	2	10	PALLET 1
	3	26	RACK 5
			RACK 6
2	4	1	RACK 3'a/b
	5	21	
3	6	3	RACK 4 a/b
	7	2	PALLET 2
		20	
	8	16B	FWD STRUCT
	9	X-2	
	10	5	
	11	2	

- Shared Spacelab Equipment Utilization-ATL

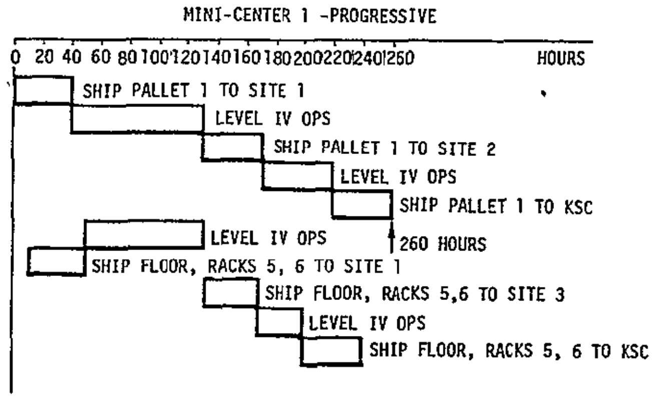
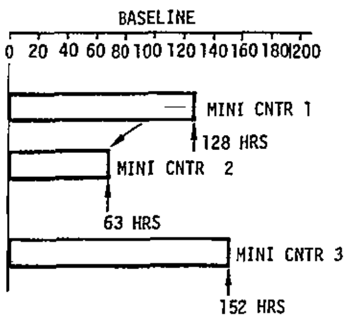


Figure 2-35. ATL Mini-Center 1 Shared Flow



MINI CENTER	SITE	EXP	EQPT
1	1	25	FLOOR
	2	10	PALLET 1
	3	26	RACK 5
			RACK 6
2	4	1	RACK 3'a/b
	5	21	
3	6	3	RACK 4 a/b
	7	2	PALLET 2
		20	
	8	16B	FWD STRUCT
	9	X-2	
	10	5	
	11	2	

- Shared Spacelab Equipment Utilization - ATL

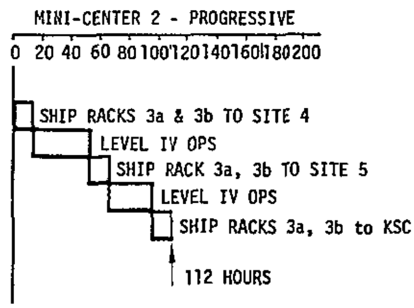
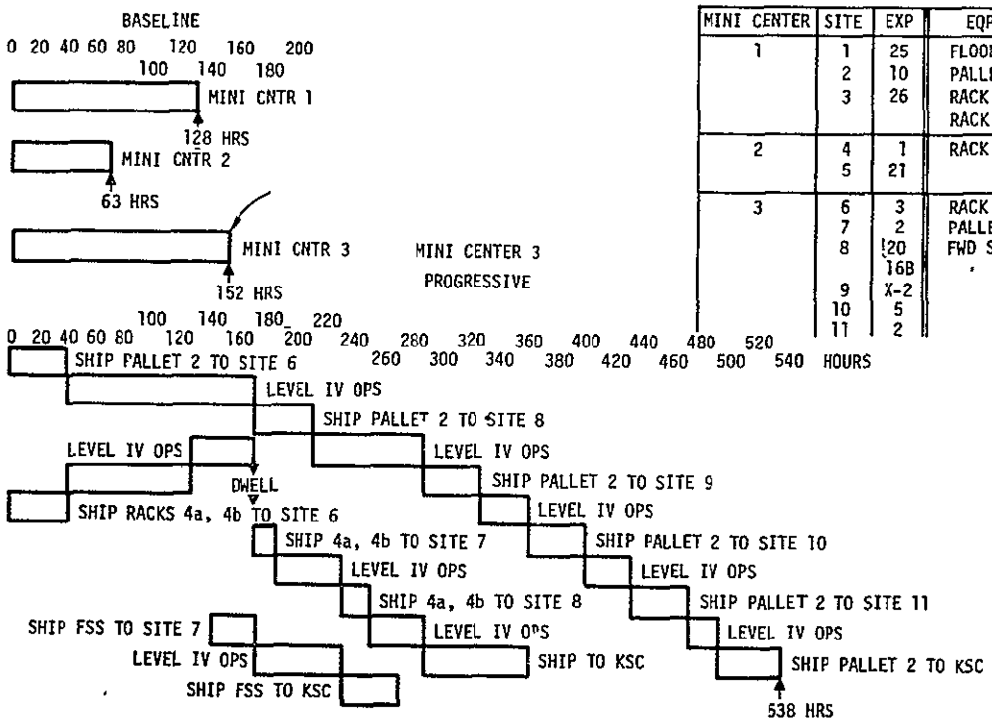


Figure 2-36. ATL Mini-Center 2 Shared Flow

● Shared Spacelab Equipment Utilization - ATL



MINI CENTER	SITE	EXP	EQPT
1	1	25	FLOOR
	2	10	PALLET 1
	3	26	RACK 5
			RACK 6
2	4	1	RACK 3 a/b
	5	21	
3	6	3	RACK 4 a/b
	7	2	PALLET 2
	8	20	FWD STRUCT
		16B	
	9	X-2	
	10	5	
	11	2	

Figure 2-37. ATL Mini-Center 3 Shared Flow

● Shared Spacelab Equipment Utilization-Combined Astronomy

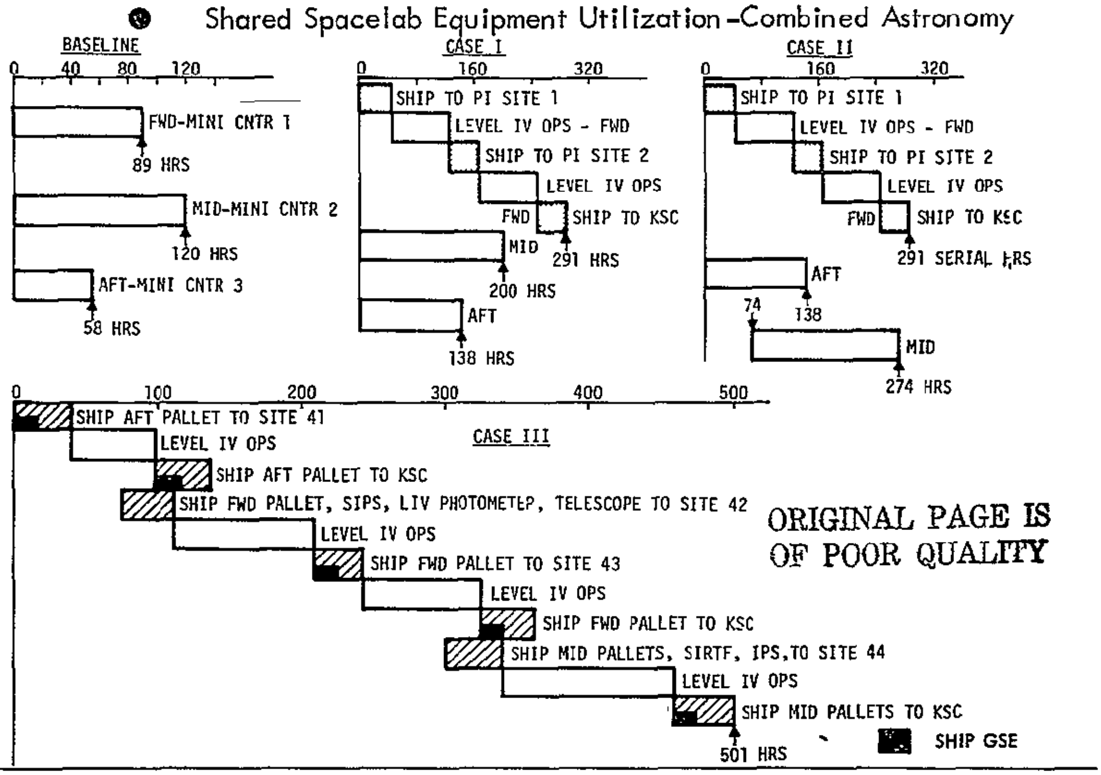


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Figure 2-38. Combined Astronomy Shared Flows

Space Processing

Space Processing utilizes only one pallet. The equipment is assigned to experiment categories designated facilities. Facility I for example, includes experiment S9A, S9B, and S21. Facility I is processed at Site No. 12. The Space Processing payload progresses from Site 12 through Site 16. Site 13 is used to process Experiment CG5 and Site 14 is used to process Experiment CG7, together they constitute Facility No. 2. Figure 2-39 illustrates the Space Processing progressive flow and includes a table showing the site, facility and experiment relationships.

The pallet for Space Processing is shipped to five different sites for Level IV integration activities. The serial time to accomplish this would be 595 hours. The processing times for each of the four experiment groupings - designated Facility I through IV - is shown in Figure 2-39 for comparison.

Life Sciences

Life Sciences, for purposes of this study, has been subdivided into equipment groupings called mini-centers. Eight mini-centers have been selected. Of these eight mini-centers, three were selected for purposes of comparison between the shared concept and the baseline for Level IV integration. Mini-Center No. 1 consists of Rack No. 3 and the associated floor section. Mini-Center No. 2 consists of Rack No. 4 and Mini-Center No. 6 consists of Rack No. 9. The experiments contained in the racks are listed in the Life Science Matrix listed in Volume I of this report. Figures 2-40, 2-41, and 2-42 show Site 1, 2 and 6 equipment installation and checkout sequences. Figure 2-43 depicts the comparison of Mini-Centers 1, 2, and 6 progressive flows compares to the baseline flows.

The Life Science experiment shared flows are shown on Figure 2-43 for three cases which were selected from the eight mini-center equipment groupings. These are cross hatched as indicated for mini-centers 1, 2 and 6. A comparison of the times for these cases and the baseline flows is presented. For example, Mini-Center No. 1 is 287 hours for the

- Shared Spacelab Equipment Utilization-Space Processing

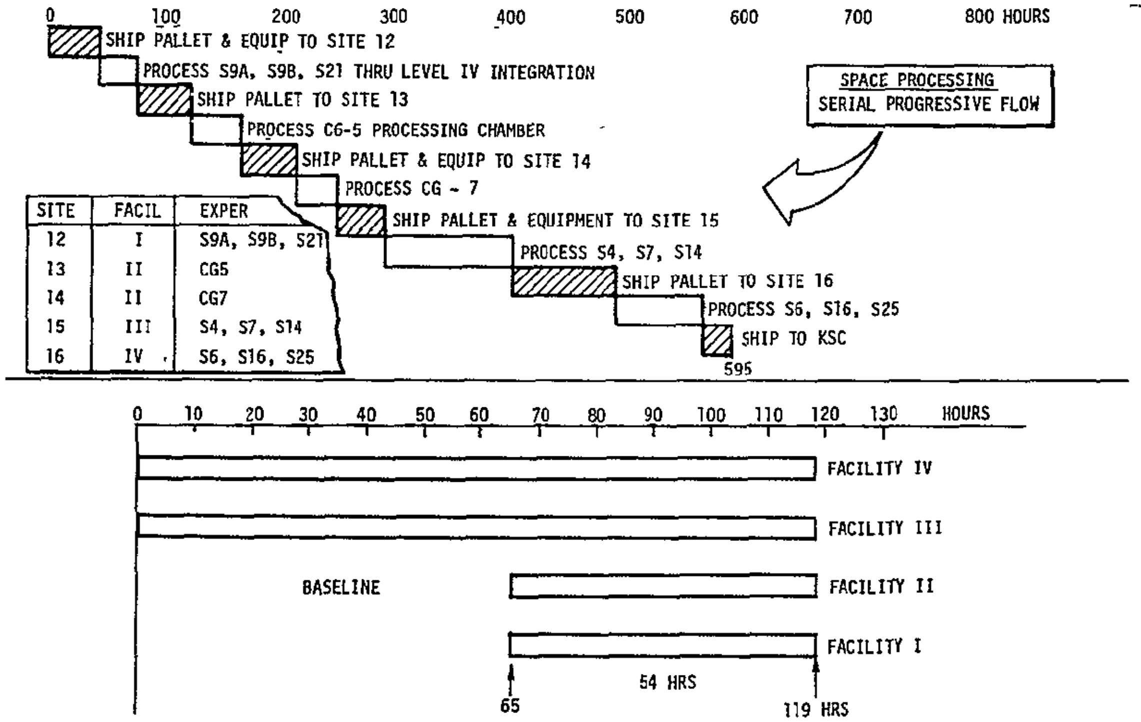

Figure 2-39. Space Processing Shared Flows

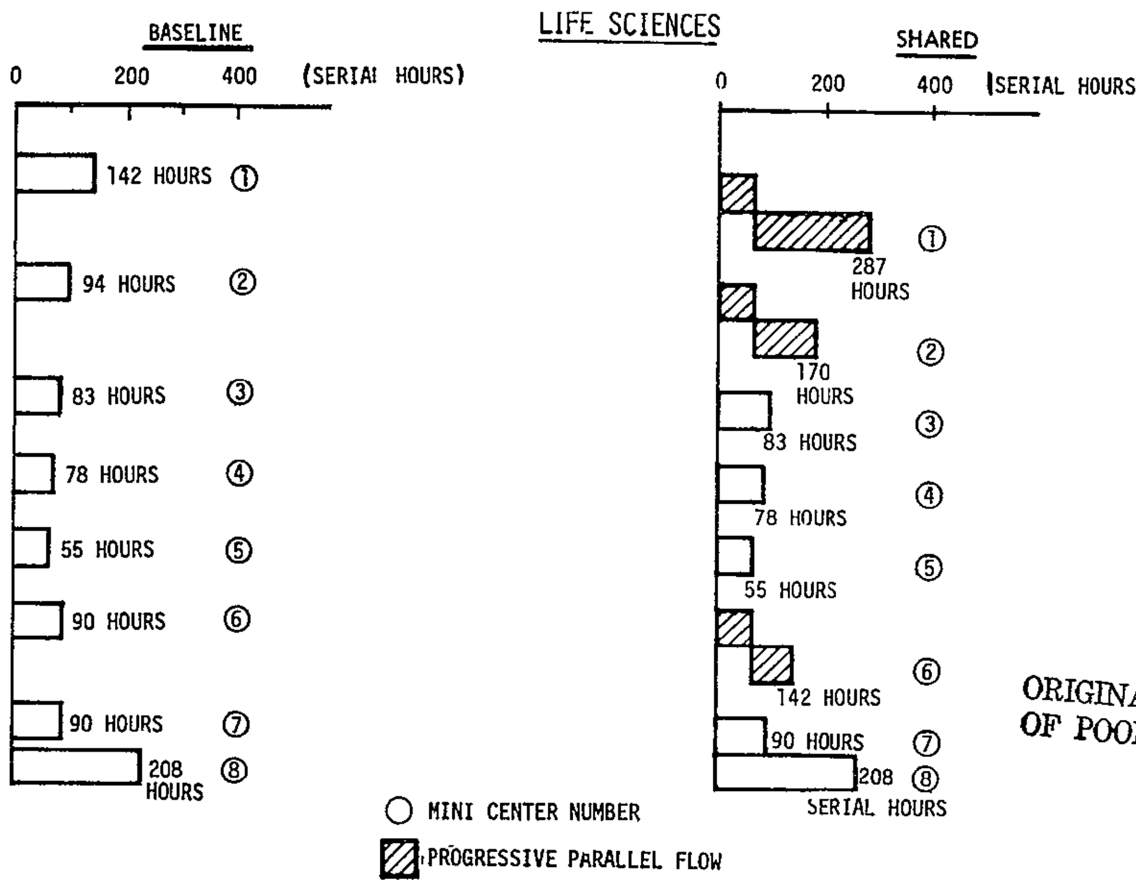

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Figure 2-43. Life Sciences Shared Flows

Manpower Costs

The manpower costs were obtained by multiplying:

hours X number of men X rate in dollars per hour

where: engineers rate = \$35 per hour
technicians rate = \$30 per hour

The manpower tasks are estimated from three categories, namely (a) Off-Site Support, (b) KSC OPS Support, and (c) Shared Level IV effort for each option. As an example, the \$205,000 listed under manpower for ATL is comprised of:

17,550	Off-Site Support
64,220	KSC OPS Support
123,500	Progressive Manpower Level IV Effort
\$205,270	Total

Temporary Duty (TDY) Costs

The TDY costs were obtained by determining the number of days and manpower involved for each activity. A charge of \$75 per man per day was used to arrive at the cost figure.

GSE Costs

The GSE costs were pro-rated for each item of equipment used per the following formula:

$$\text{Cost} = \frac{\text{Days Involvement X Unit Cost of Equipment}}{\text{250 Working Days Per Year x 10 Year Life}}$$

Spacelab Flight Hardware Costs

The S/L FLT Hardware Costs were developed using the dedicated rule which states that once an item of equipment is selected for a mission it is dedicated for that use until the mission is completed. The cost is developed using the same formula as was used for determining the GSE costs.

Transportation Costs

Transportation Costs were developed using guidelines including those listed below:

A) To ship via outsized carriers (in excess of 8 ft. width) for
   1) Pallet Segment/Pallet Train
   2) Long Module Rack/Floor Set
      Shipping Time - 5 working days at 40 hours
      Cost - $4000

B) To ship via standard carriers (within 8 ft. width)
   1) Racks, Floor Segments, Short Modules
   2) GSE
   3) Experiment Equipment Shipping Containers
      Shipping Time - 2 working days or 16 hours
      Cost - $3000

C) To ship an outsized shipping container (in excess of 8 ft. width)
   Shipping Time - 2 working days
   Cost - $1500

Total Dollars Per Flight

Table 2-29 summarizes all of the cost factors for a mission for each of the four payloads for the shared flow option selected.

Baseline

The baseline costs are the total costs for the option selected for each of the four payloads. For example, option A-3 baseline for the ATL is $559,000. This option includes activity blocks 5, 6, 7, 8, 9, 10 and 16. The identification of each activity block is listed below.

Activity Block No.	Description
5	Individual Experiment Rack/Pallet Installation
6	Individual Experiment Interface Verification
7	Interim Payload Interconnect
8	Combined Payload Checkout
9	Disassembly for Shipments
10	KSC Level III Buildup Assembly Racks/Floor Pallets
16	Spacelab Deintegration

Delta Over Baseline

The difference between the baseline cost and the Shared Trade Cost is shown in this column. In all cases, this difference is positive (greater than) the baseline.

Table 2-29. Summary of Shared Trades Cost Data

(K $)	OPTION	MANPOWER	TDY	GSE	SL FLT HARDWARE	TRANSPORTATION	TOTAL $/FLT	BASELINE	DELTA OVER BASELINE
COMBINED ASTRONOMY	A-2								
	CASE I	218	13	23	1,141	45	1,440	1,348	92
	CASE II	218	13	22	1,175	39	1,467	1,348	119
	CASE III	218	13	25	1,252	116	1,624	1,348	276
LIFE SCIENCES	A-1	224	41	21	73	83	442	389	53
	A-3	243	44	22	80	83	472	422	50
SPACE PROCESSING	A-2	114	9	10	166	28	327	249	78
ADVANCED TECHNOLOGY LAB	A-3	205	3	25	328	75	636	559	77

Summary

The results of the comparisons of progressive flows and baseline flows for all experiments is presented in Table 2-29. The results are expressed in thousands of dollars for each case. As can be seen, the delta over the baseline is positive in all cases. In the results for Case III for Combined Astronomy, a delta of $276,000 is shown. This case represents the minimum sets of GSE and checkout equipment and the maximum serial checkout time. The involvement time required for the GSE and flight hardware as well as transportation costs contribute to drive the total cost higher than in Case I and II as well as the baseline.

3.0 LEVEL IV GROUND PROCESSING REQUIREMENTS - BASELINE

3.0 LEVEL IV GROUND PROCESSING REQUIREMENTS - BASELINE

3.0

LEVEL IV GROUND PROCESSING REQUIREMENTS - BASELINE TRAFFIC MODEL

SCOPE OF PROGRAMMATIC ANALYSES

This section describes the programmatic analyses that were performed during the study. It includes an overview of the ground processing options that were considered plus the rationale for the selection of the 6 options studied in detail. A listing of the basic guidelines used in the programmatic analyses has been itemized. An introduction to the resource categories is included.

This section also discusses the relationship of the reference traffic model (viz. the "560" traffic model) with the payload equivalency model used in the study. A buildup analysis based on ground processing times were performed and are included along with a schedule analysis reflecting the development of payload launch dates.

Spectrum of Options

Three Level IV integration ground processing concepts were considered; distributed site, centralized site, and launch sites. The distributed site concept reflected multiple level IV integration activities for a single Spacelab payload at geographically separated locations. The centralized site concept required all experiment equipment and Spacelab mounting/interfacing hardware for a payload at one geographical location. The third concept required all experiment hardware at the launch site, KSC.

All three concepts reflected the same level of assembly and checkout prior to initiation of level III/II integration activities at KSC. Preliminary assessment of the data being developed for each payload for each concept indicated only minor differences, which could be attributed primarily to variations in transportation requirements. In an attempt to provide a broader spectrum of data, Rockwell expanded the number of options to be considered. The expansion within the three baseline or generic concepts was based upon variations in the experiment/payload integration.

DISTRIBUTED SITE OPTIONS

The principal characteristic of distributed site options is the independent buildup and checkout of Spacelab mounting elements at multiple geographical locations. For example, an experiment system could be installed and checked out in one rack at a site, while other experiment systems were being installed and checked out independently in other racks at other sites. Multiple sets of checkout equipment are also characteristic of this generic concept.

The variations within the generic distributed site concept pertain to the level of payload assembly and checkout activities prior to initiation of level III/II integration activities of the KSC-STS operations. One option (designated A-1) reflects rack/floor and/or pallet train assembly in the STS operations. Also, in the A-1 option, the initial

checkout of the integrated payload is accomplished after rack/floor installation into the module, interconnection of the habitable module and pallet(s), and/or installation of the igloo on the lead pallet and interconnection of pallets.

A functional flow diagram for this option is presented in Figure 3-1. A description of the activities conducted in each block is presented in Table 3-1. The missing number will be subsequently assigned and the activities identified in subsequent option definitions.

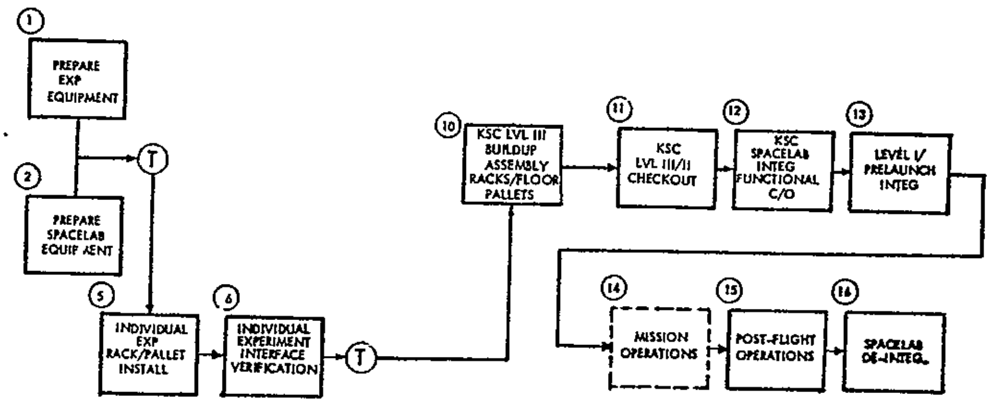

Figure 3-1. Individual Experiment Integration - Level III/II Assembly and Checkout

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Table 3-1 Individual Experiment - III/II Assembly Functional Descriptions

Functional Block	Title	Descriptor
1	Prepare Experiment Equipment	Receiving and inspection of experiment equipment at the level IV site. Preparation for move/transfer to the level IV integration area
2	Prepare Spacelab Equipment	Reconfiguration of Spacelab flight hardware to specific configuration and complement of interfacing Spacelab elements required for next payload. Conducted at KSC as part of staging operation. Includes installation of RAU's, I/C's, EPSP/EPDB's, Cold plates, etc.
5	Individual Experiment Rack/Pallet Installation	Installation of intra-rack/pallet cable/fluid lines, mounting of experiment hardware in racks, on floor segments, and on pallet segments Multiple independent assembly activities conducted as a function of viable subdivision of Spacelab mounting elements and experiment systems for an individual payload (e.g. single rack, rack set, rack/floor segment, rack/pallet, pallet segment, etc).
6	Individual Experiment Interface Verification	Functional checkout of interfaces established in block 6. Includes electrical and fluid interconnections. Conducted on individual experiment system basis. Interfaces may or may not be maintained in subsequent transfers and buildups. Includes intra-rack/pallet connections and interfaces between experiment hardware and Spacelab interfacing elements such as RAU's, EPSP/EPDB's, I/C, etc.
10	KSC Assembly Racks/Floors/Pallets	Assembly of subdivided Spacelab mounting element/experiment system (see block 5 description) into payload flight configuration Includes rack/floor assembly into a short module/long module configuration and mating of pallet segments into pallet trains. Part of KSC-STS-O&C building operations and referred to as level III assembly activity.
11	KSC Assembly With Electrical/Environmental System and Command/Control System	KSC-STS operations which include installation of rack/floor sites in modules, interconnection of Spacelab and experiment system, installation of end core, pallet and/or pallet train interconnections, and installation of Igloo (as applicable).
12	KSC Spacelab Integrated Functional Checkout	Functional verification of all electrical and fluid interfaces established in blocks 10 and/or 11 Includes Spacelab subsystem, Spacelab/experiment and intra-experiment connections, data/command transfer interfaces, CDMS/experiment software, and loading/stowage of loose experiment equipment.
13	Level I/Pre-Launch Integration	OPF and Pad operations. Includes installation of Spacelab/payload into Orbiter bay and dedicated payload control and display panels in Orbiter Aft-Flight-Deck (AFD), functional verification of all electrical and fluid interfaces established during installation, servicing/top-off of payload fluids/consumable, and loading of specimens.
14	Mission Operations	Reference period of seven calendar days to be used in determination of flight hardware involvement times.
15	Post-Flight Operations	Safing of experiment system and off-loading of critical samples, specimens, data prior to O&C building operations.
16	Spacelab De-integration	Removal of rack/floor sets from modules, disassembly of pallet/pallet trains, removal of experiment hardware from Spacelab mounting elements.

The second distributed site option (A-2) reflects combined payload checkout at KSC after independent/individual experiment/mounting element integration at multiple distributed sites but prior to entering STS operations in the O&C building. For purposes of this study, it was assumed that the off-line combined payload checkout activity at KSC would occur in an industrial complex facility. This option is also characterized by the by-passing of the level III assembly activity in the O&C building. For example, independently integrated pallets or pallet trains (pallet-only payload) would be interconnected and checked out at the payload level in the off-line activity, disconnected, and then transported directly to the level II stand in the O&C building.

The third distributed site option (A-3) also includes off-line checkout at the payload level at KSC. However, in this option, level III assembly in the O&C building is required. For example, rack/rack sets from multiple distributed sites would be interconnected and checked out in the off-line activity, disconnected and transported to the O&C building, and then integrated with floor segments in the level III assembly stand.

A functional flow diagram for the A-2 and A-3 options is presented in Figure 3-1. The delta activities for these options are reflected in functional blocks 7, 8 and 9. All other functional blocks are essentially the same as described in Table 3-1. Activities in blocks 7, 8, and 9 are summarized in Table 3-2. The destination from block 9 is dependent upon the configuration of the payload upon arrival at the O&C building. If the payload is in the flight configuration, the flow by-passes block 10 (Option A-2). If level III assembly is required, block 10 is included in the processing flow (Option A-3).

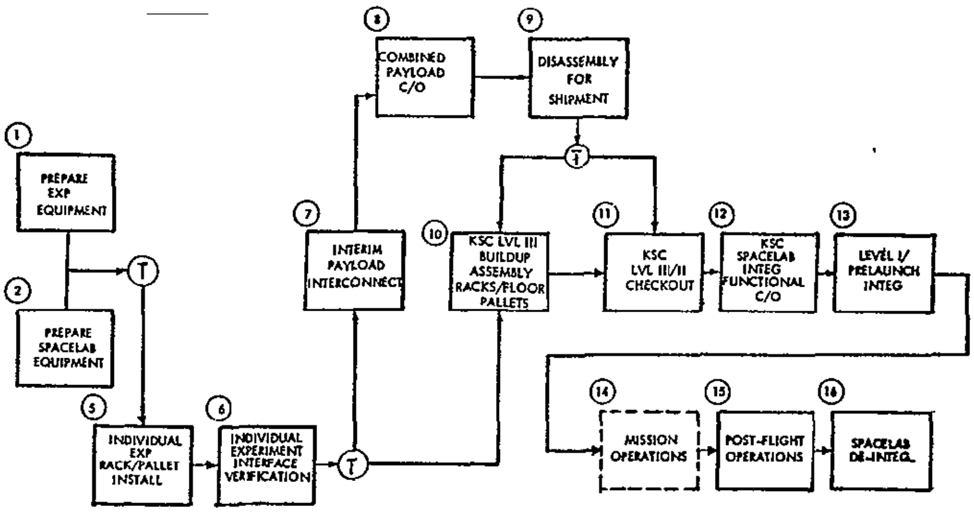

Figure 3-2. Individual Experiment Integration - Pre-Level III/II Combined Checkout

Table 3-2. Delta Activities for Individual Experiment Integration - Pre III/II Combined Checkout

Functional Block	Title	Descriptor
3	Experiment Installation and Payload Assembly	Installation of experiment equipment in the flight configured rack/floor sets and/or pallet trains. Assembly of Spacelab mounting element/experiment system into payload flight configuration. Includes rack/floor assembly into a short module/long module configuration and mating of pallet segments into pallet trains.
4	Experiment Interface Verifications	Includes the sequential and progressive verification of individual experiment systems and of the interfaces established in Block 3. Includes electrical and fluid interconnections Verifications and functional tests conducted on a completed payload configuration. Interfaces may or may not be maintained in subsequent transfers and buildup.
7	Interim Payload Interconnect	Assembly and/or interconnection of individually integrated Spacelab mounting element/experiment systems into a simulated flight configuration.
8	Combined Payload Checkout	Functional verification of multiple experiment/simulated Spacelab system interfaces. Includes. command/data transfer, power/cooling compatibility, and CDMS/experiment software.
9	Disassembly for Shipment	Dependent upon payload buildup approach and location of combined payload checkout. If payload is in flight configuration at KSC only preparation for transfer to O&C building is required. If transportation width is a constraint (>12 feet) disassembly of long module rack/floor and pallet trains is required. If configuration is only simulated flight configuration individually integrated Spacelab mounting elements must be prepared for shipment.

LEAD CENTER OPTIONS

The generic lead center concept is characterized by the performance of all pre-O&C building integration activities at one geographical location other than KSC. The options within this concept reflect variations in both the level of and approach to assembly and checkout.

The first three lead center options are similar to the distributed site options. Although experiment system/mounting element integrations are conducted on an individual basis, the activities are scheduled to maximize the common usage/sharing of GSE. The first option (B-1) would result in the integration of individual mounting element at a lead center. Subsequently, these elements would be transferred to KSC for assembly into the flight configuration of the payload in the O&C building. Option B-1 is comparable to option A-1.

Options B-2 and B-3 are comparable to options A-2 and A-3 with regards to pre-KSC/STS assembly and checkout status. However, the combined payload checkout activity would be conducted at the lead center rather than in an off-line facility at KSC. Except for the location(s) of this activity the functional blocks in Figure 3-1 and -2 for options A-1, A-2, and A-3 are the same for B-1, B-2, and B-3, respectively.

If level IV integration is conducted at one geographical location installation of the full complement of experiment equipment and/or Spacelab mounting elements prior to checkout is feasible. Option B-4 reflects this possibility. For example, an entire rack/floor set would be available at the level IV site. Intra- and inter-rack and floor cabling would be installed. Experiment equipment would be installed in/on the racks and floor segments. Individual experiment systems would be checked out followed by a combined payload checkout. The totally assembled and integrated payload would then be transported directly to the level II stand in the O&C building.

In order to assess the impact on ground processing of a potential road transportation constraint, a fifth lead center option (B-5) was introduced. Repetitive road transportation through some states may be restricted to a maximum width of twelve feet. This constraint can be met if only single pallet and/or single module rack/floor sets are transported. Thus, for the B-5 option, payload assembly and preparation for shipment activities in the B-4 option were revised to reflect the temporary interconnection of pallet trains and long module rack and floor sets. Also, the level III assembly activity in the O&C building was included in the KSC-STS operations.

The top level functional flow for the B-4 and B-5 options is presented in Figure 3-3. Only functional blocks 3 (Experiment Installation and Payload Assembly) and 4 (Experiment Interface Verifications) are deltas to the flow presented in Figure 3-1. Block 3 encompasses the installation of experiment equipment in flight configured rack/floor sets and/or pallet trains. Block 4 includes the sequential and progressive verification of individual experiment systems. The activities within blocks 8, 9, and 10 are similar to those of the previously discussed options, but reflect the integrated payload configuration of options B-4 and B-5.

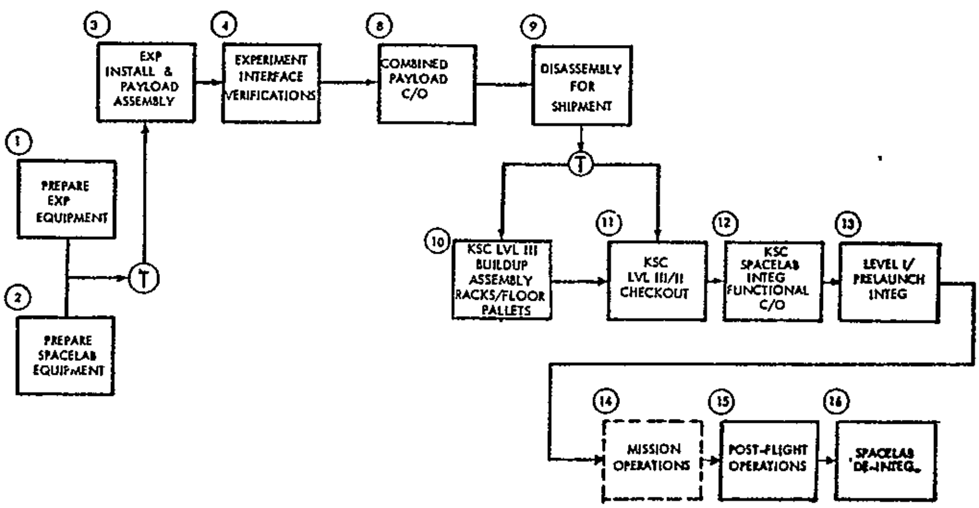

Figure 3-3. Payload Assembly and Checkout - Disassembly for Transportation

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KSC OPTIONS

In general, the KSC options are a special application of the lead center options. All experiment equipment and Spacelab mounting elements are integrated at one geographical location, KSC. For purposes of this study, it was assumed that all the level IV integration activities at KSC would be conducted in a facility in the industrial complex. The one disparity between the lead center options and the KSC options is that there is no KSC option comparable to B-5. A twelve-foot width constraint during transporation of an integrated payload from the industrial complex to the O&C building at KSC is not applicable.

SUMMARY OF GROUND PROCESSING OPTIONS

A composite of the functional flows for the processing options is presented in Figure 3-4. A matrix of the twelve options for the three generic concepts and the applicable functional blocks is presented in Figure 3-5. As stated previously, the first three options for each generic concept encompass the same functional blocks (activities). Options B-4 and C-4 are comparable; Option B-5 is unique to the lead center concept.

The predominant discriminators between options are as follows:

1. Level of pre-KSC/STS integration: Inclusion/exclusion of Combined Payload Checkout - Block 8.

2. Approach to experiment installation: Individual experiment versus payload buildup - blocks 5 and 6 versus blocks 3 and 4.

3. Level III assembly at KSC: Inclusion/exclusion of payload flight configuration buildup at KSC - block 10.

Variations combinations of A, B, and C options for the ground processing of a payload were briefly examined. Some combinations or hybrids are feasible and quite reasonable. For example, part of a payload might be integrated at a distributed site (A type option) and then combined with the remainder of a payload at a lead center (B type option) prior to transfer to KSC. The assessment of these types of hybrid options would not significantly expand the spectrum of data of the basic twelve options. Also, the data for the twelve options could be extrapolated to various hybrids if other factors indicated the desireability of a hybrid ground processing approach for an individual payload.

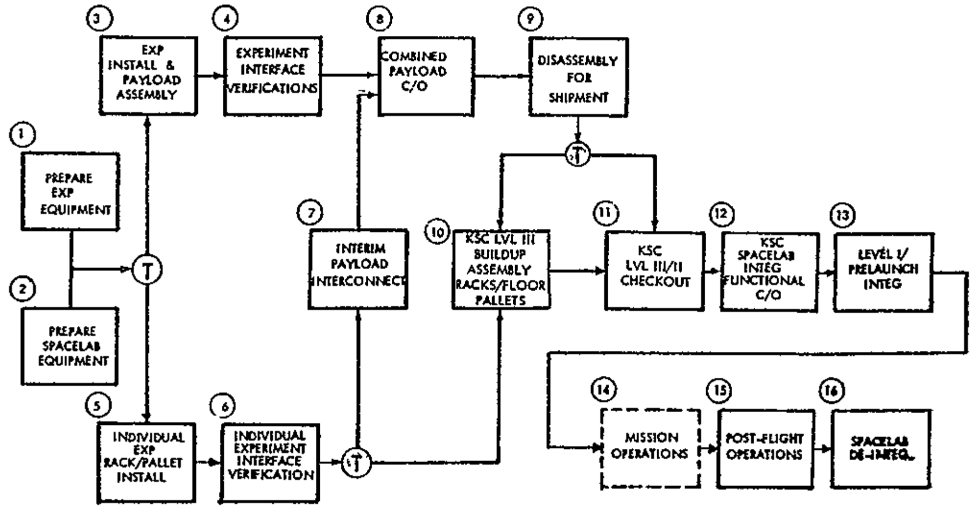

Figure 3-4. Ground Processing Options - Top Level Functional Flow

OPTION	DESCRIPTOR	APPLICABLE ACTIVITY BLOCK 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A-1	IND EXP C/O	PI	LS			D	D				LS	LS	LS	LS	LS	LS	LS
A-2	IND EXP C/O-INT EXP C/O-ONLA	PI	LS			D	D	LS	LS	LS		LS	LS	LS	LS	LS	LS
A-3	IND EXP C/O-INT EXP C/O-OFLA	PI	LS			D	D	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS
B-1	DEP EXP C/O	PI	LS			C	C				LS	LS	LS	LS	LS	LS	LS
B-2	DEP EXP C/O-INT EXP C/O-ONLA	PI	LS			C	C	C	C	C		LS	LS	LS	LS	LS	LS
B-3	DEP EXP C/O-INT EXP C/O-OFLA	PI	LS			C	C	C	C	C	LS	LS	LS	LS	LS	LS	LS
B-4	P/L ASSEMBLY-C/O- ONLA	PI	LS	C	C				C	C		LS	LS	LS	LS	LS	LS
B-5	P/L ASSEMBLY-C/O- OFLA	PI	LS	C	C				C	C	LS	LS	LS	LS	LS	LS	LS
C-1	DEP EXP C/O	PI	LS			LS	LS				LS	LS	LS	LS	LS	LS	LS
C-2	DEP EXP C/O-INT EXP C/O-ONLA	PI	LS			LS	LS	LS	LS	LS		LS	LS	LS	LS	LS	LS
C-3	DEP EXP C/O-INT EXP C/O-OFLA	PI	LS			LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS
C-4	P/L ASSEMBLY-C/O-ONLA	PI	LS	LS	LS				LS	LS		LS	LS	LS	LS	LS	LS

LEGEND-

A-X DISTRIBUTED SITE OPTIONS
B-X CENTRALIZED SITE OPTIONS
C-X LAUNCH SITE OPTIONS

IND INDEPENDENT
EXP EXPERIMENT
C/0 CHECKOUT
OFLA OFF-LINE ASSEMBLY
D DISTRIBUTED SITE
LS LAUNCH SITE

ONLA ON-LINE ASSEMBLY
DEP DEPENDENT
INT INTEGRATED
P/L PAYLOAD
PI PRINCIPAL INVESTIGATOR
C CENTRALIZED SITE

Figure 3-5. Matrix of Processing Options

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Options Selected for Programmatic Evaluation

Six sets of ground processing options were analyzed to determine programmatic implications. The selection of these sets was based upon the following criteria:

1. Reflect the maximum spectrum of assembly and checkout prior to KSC-STS operations between generic ground processing concepts (Distributed, centralized, KSC).

2. Reflect the maximum spectrum of assembly and checkout prior to KSC-STS operations within generic concepts.

3. Reflect the maximum spectrum of Level IV integration GSE requirements.

4. Reflect the maximum spectrum of Level IV integration transportation requirements.

A generalized application of these criteria to the matrix of 12 processing options indicated that distributed site options A-1 and A-3, centralized site options B-1 and B-4, and KSC options C-1 and C-4 were preferred. The A-1, B-1, and C-1 options reflected only individual experiment/mounting element integration prior to initiation of KSC-STS operations. The A-3, B-4, and C-4 options reflected the maximum level of integration of the payload within a generic option prior to KSC-STS operations. Transportation and GSE extremes are reflected between distributed site options (A-1 and A-3) and KSC options (C-1 and C-4).

A minor deviation from the generalized approach was required for the two pallet only representative payloads, Space Processing and Combined Astronomy. KSC-STS level III assembly, which would correspond to an A-3 option not requiring Block 10, was not required for the Space Processing payload. The A-3 option contains Block 10 "KSC off-line assembly of racks/floor and pallets" for a single pallet payloads such as Combined Astronomy is activity that is not required. Therefore, the A-2 option (no KSC-STS Level III assembly) will be used for the Space Processing payload in conjunction with the A-3 options for the other payloads.

Conversely, the Combined Astronomy payload, which has canisters to be installed in the SIPS, does require Level III KSC-STS assembly regardless of the option used due to the multiple pallets and experiments. Therefore, the B-3 and C-3 options for the Combined Astronomy payload will be used in conjunction with the B-4 and C-4 options, respectively, for the other payloads.

The payload ground processing options and programmatic sets that were analyzed are summarized in Table 3-3.

Table 3-3. Payload Options Used - Programmatic Analyses

Data Set \ Payload	Combined Astronomy	Space Processing	Life Science	ATL
1.	A-1	A-1 *	A-1	A-1
2.	A-3	A-2	A-3	A-3
3.	B-1	B-1 *	B-1	B-1
4.	B-3	B-4	B-4	B-4
5.	C-1	C-1 *	C-1	C-1
6.	C-3	C-4	C-4	C-4

* Data input to options A-2, B-2 and C-2 were revised to reflect deletion of the combined payload checkout activity of functional blocks 7, 8, and 9. Activity not required since all experiments are in a single pallet.

Programmatic Guidelines

The basic guidelines that were used in the programmatic analyses are as follows:

1. Mission Model: The "560" traffic model will be used as the baseline.

2. Payload Equivalency: The equivalency between the representative payloads used in this study and the payloads in the traffic model.

3. Launch Schedule: Within the constraints of the types of Spacelab configurations scheduled for any year, launches will be equi-spaced and alternate between pallet-only and habitable module configurations. For example, if six launches of each configuration are scheduled in a year, launches of alternating configurations will be scheduled at the rate of one per month. Where possible, launches of each category of payload will also be equally spaced. That is, if 4 ATL type payloads are scheduled in a year, one would be scheduled to be launched every three months.

4. Learning Curve: An 80 percent learning curve will be used to extrapolate ground processing times appropriate to the operational era to initial payload integration activities. This learning curve will be applied to the first five flights or two years of operation, which ever is less, for each of the four categories of payloads of the traffic model.

5. Resource Requirements: The programmatics analysis will result in the definition of hands-on personnel, Level IV Spacelab related GSE, Spacelab interfacing hardware, transportation (to/from Level IV sites), and major Spacelab flight hardware requirements.

   The manpower estimates will be adjusted to reflect personnel requirements rather than manhours. This results in a more realistic estimate of the manpower requirement deleting spikes in the personnel curve; however, it does result in an increase in manpower costs. Annual salaries will not be reflected in the manpower costs. That is, if a technician is required for two months of a year, then only one-sixth of his annual salary will be included in the programmatic cost compilations.

   Interfacing hardware that will be specifically identified will be: racks, pallet segments, IPS, SIPS, RAU's, EPDB's, floors, and cold plates.

   One SIPS will be assumed for each combined astronomy payload plus one additional one in the inventory to accommodate periodic 2 SIPS payloads. One IPS will be assumed for every other combined astronomy payload.

6. Cost Estimating: All resources will be costed in 1977 dollars. Inflation rates will be compounded at the rate of 10% per year for European supplied equipment and 7% per year for all other resources.

Programmatic Resource Categories

For each of the six options evaluated during the programmatics analysis, there were four major resources categories that were analyzed. These four are:

- Personnel Requirements
- Level IV Integration GSE
- Spacelab Flight Hardware Requirements
- Transportation Costs

The personnel requirements covered the categories of direct "hands-on" integration manpower, Host Center support and PI support for KSC Operations. The Level IV integration manpower requirements as well as the TDY and support level of PI's at KSC during the STS Operations.

The Level IV integration GSE analysis evaluated these GSE end items required to support the Spacelab equipment utilized during the Level IV integration activities. It represents that GSE required as a result of the installation and checkout activities relating to the Level IV integration of the experiments and the Spacelab flight hardware.

The third resource category is the Spacelab flight hardware. In this analysis, the required inventory of flight hardware needed to support each of the six ground processing options evaluated was derived from an analysis of the serial ground processing flows (involvement times), the specific payload configuration of each representative payload, and the launch rate and schedule of the traffic model being evaluated.

The transportation resource category includes those costs associated with the shipment of Spacelab flight hardware and GSE from the various level IV integration sites to the launch site. It also contributes to the overall ground processing serial timelines by defining the time allocated to the equipment shipments.

These four resource categories are defined in detail, for the Baseline Traffic Model, in the next four subsections. These corresponding subsections are also discussed for the 2/3 and 1/3 Baseline traffic model analysis of sections 4.0 and 5.0.

TRAFFIC MODEL ANALYSIS

Payload Equivalencies

The traffic model baseline used in this study was the "STS Traffic Manifest, 1980 - 1991" dated December 1976. This model contains the representative types of payload activity being planned for the Shuttle. The missions reflect the generic payloads over a 12 year period from 1980 through 1991.

Accommodation of the generic payload types resulted in a requirement of 560 Shuttle flights throughout the fiscal year time frame including abort reflects and 83 expendable launch vehicle flights. The following table (Table 3-4) is a summary of the Spacelab flights that are in the total "560" traffic model that was used as a baseline.

Table 3-4. 560 MISSION MODEL

SPACELAB AND SPACE STRUCTURES

PAGE 1 OF 2

CODE	PAYLOAD	CONFIG.	UP WEIGHT (KG)	DOWN WEIGHT (KG)	TOTAL LENGTH (M)	ORBITAL INCL (DEG)	ORBITAL ALT (NM)	MISSION DURATION (DAYS)	80	81	82	83	84	85	86	87	88	89	90	91	EQUIV FLTS	TOTAL
AS–01	ASTROPHYSICS	5 PALLETS	14,515	14 515	16 5	28 5	189	7				1	2	2	1	1	1	1	1	1	11	11
AS–01		5 PALLETS	14,515	14,515	16 5	28 5	189	14							1	1	1	1	1	1	6	6
SU–1		5 PALLETS	14,570	14,678	16 5	28 5	215	7						2	2	2	2	2	2	2	14	14
IR–1		5 PALLETS	14,515	14 515	16 5	28 5	215	7								1					1	1
									0	0	0	1	2	4	4	5	4	4	4	4	32	32
SU–2	SOLAR TERRESTRIAL	5 PALLETS	16,170	13,060	16 5	90	190	7							1		1		1		3	3
SU–2		5 PALLETS	16,170	13,060	16 5	90	190	14						1		1		1		1	4	4
SU–3		5 PALLETS	16,170	13 060	16 5	90	190	7						1		1		1		1	4	4
		5 PALLETS	16,170	13,060	16 5	90	190	14							1		1		1		3	3
AP–06		SH MOD+3 PALLETS	15,120	13,520	18 3	90	140X230	7				1	2	2	1	1	1	1	1	1	11	11
AP–03		SH MOD+3 PALLETS	15,120	13,520	18 3	90	140X230	14							1	1	1	1	1	1	6	6
									0	0	0	1	2	4	4	4	4	4	4	4	31	31
PA–1	PHYSICS AND ASTRONOMY	5 PALLETS	14,515	14,515	16 5	28 5	190	7			1	3	3	3	3	3	3	3	3	3	28	28
									0	0	1	3	3	3	3	3	3	3	3	3	28	28
LS–09	LIFE SCIENCES	LONG MODULE	10,735	10,125	15 3	28 5	200	7		2	2										4	4
LS–02		LONG MODULE	10,735	10,125	15 3	28 5	200	30				2	2	2	2	2	2	2	2	2	18	18
									0	2	2	2	2	2	2	2	2	2	2	2	22	22
ATL–1	SPACE TECH	SH MOD+3 PALLETS	10,770	10,770	16 8	50	240	7		1	1	1	1	2	1						7	7
ATL–1		SH MOD+3 PALLETS	10,770	10,770	16 8	50	240	14								2	1	2	1	2	8	8
								–		1	1	1	1	2	1	2	1	2	1	2	15	15
	MULTI USER APPLICATIONS																					
MU80–0	OA,OSS,OAST, ESA	LONG MOD + PALLET	14 890	14,515	18 3	57	175	7	1												1	1
MU81–0	OA,OSS	4 8 PALLETS	16,280	14,515	13 5	35	245	7		1											1	1
MU81–1	OA,OSS OAST	LONG MOD + PALLET	14,460	14,100	17 6	ANY	220	7		1	1	1	1	1							5	5
MU81–1	OA,OSS,OAST	LONG MOD + PALLET	14,460	14,100	17 6	ANY	220	14				1	1	1							3	3
MU81–2	OA,OAST,ESA	SH. MOD + 3 PALLETS	13,120	12,710	18 3	57	175	7		1											1	1
MU82–2	OA,ESA	LONG MOD + PALLET	14,050	13,490	18 3	55	245	7			1			•							1	1
MU82–3	OA,OAST,OSS,ESA	LONG MOD + PALLET	12,600	12,190	18 3	56	190	7			1										1	1
MU83–2	OA,OAST	LONG MOD + PALLET	14,460	14,070	18 3	28 5	216	7				1	1	1							3	3
MU83–3	OA,OAST	SH MOD+ 3 PALLETS	13,110	9,435	18 3	ANY	135	7				1	1		1	1	1	1	1	1	8	8
MU83–3	OA,OAST	SH MOD+ 3 PALLETS	13,110	9,435	18 3	ANY	135	14						1	2	2	2	2	2	2	13	13
MU84–1	OA	SH MOD+ 3 PALLETS	13,120	12,710	16 3	28 5	190	7					1	1							2	2
MU86–1	OA,OSS	LONG MOD + PALLET	14,400	14,100	17 4	ANY	220	7							2	2	2	2	2	2	12	12
									1	3	3	4	5	5	5	5	5	5	5	5	51	51
							TOTAL		1	6	7	12	15	20	19	21	19	20	19	20		179

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Table 3-4 (Cont'd) 560 MISSION MODEL

SPACELAB AND SPACE STRUCTURES (CONTINUED)

CODE	PAYLOAD	CONFIGURATION	UP WEIGHT (KG)	DOWN WEIGHT (KG)	TOTAL LENGTH (M)	ORBITAL		MISSION DURATION (DAYS)	LAUNCH SCHEDULE												EQUIV FLTS	TOTAL
						INCL (DEG)	ALT (NM)		80	81	82	83	84	85	86	87	88	89	90	91		
	NON NASA/NON DOD																					
CSP 01S	CIVIL SPACE PROCESS	LONG MOD + 1 PALLET	14,515	14,515	16 4	28 5	156	7						1	1	2	2	2	2	2	12	12
COM-1	PRIVATE IND GPL	LONG MOD + 1 PALLET				ANY	190	7						1	1	1	1	1	1	1	7	7
														2	2	3	3	3	3	3	19	19
	FOREIGN SPACELAB																					
FSP 01S	FOREIGN SPACE PROC	LONG MOD + 1 PALLET	14,515	14,515	16 4	28 5	156	7						1		1	1	1	1	1	6	6
ASN-01	FOREIGN ASTRONOMY	IGLOO + 2 PALLETS	5,900	5,900	7 4	28 5	194	7				1		1	1	1	1	1	1	1	4	4
CSN-01	CANADIAN SCIENCE	IGLOO + 2 PALLETS	5,500	5,500	7 4	57	194	7								1		1			1	2
SPN-SP	ESA	1 PALLET	4,800	4,800	3	ANY	156	7				1	1	1	1	1	1	1	1	1	2¼	9
GPN-SP	W. GERMANY	1 PALLET	4,800	4,800	3	ANY	156	7				3	3	3	2	2	2	2	2	2	5¼	21
EON-50	ESA-EARTH OBS	SH MOD+ 3 PALLETS	12,200	11,750	16 4	28 5	190	14					1		1		1		1	1	5	5
EON-51	ESA-EARTH OBS	SH MOD+ 3 PALLETS	12,200	11,750	16 4	90	190	7					1		1		1		1		4	4
EON-51	ESA-EARTH OBS	SH MOD+ 3 PALLETS	12,200	11,750	16 4	28 5	190	14				1		1		1		1		1	5	5
GPN-1	ESA-GPL	SH. MOD+ 3 PALLETS	11,900	11,560	16 4	28 5	190	7						1		1		1	1	1	5	5
												6	6	8	6	8	7	8	8	8	37½	85
	SPACE INDUSTRIALIZATION																					
SS-07	LARGE SPACE STRUCTURES		18,140	2,000	15.2	28 8	216	7		2	2	2	3								9	9
SS-08	RESUPPLY		13,600	4,535	14 0	28 8	216	10						3	3	3	4	4	4	4	25	25
										2	2	2	3	3	3	3	4	4	4	4	34	34
								TOTAL	0	2	2	8	9	13	11	14	14	15	15	15		118
								EQUIV FLTS	0	2	2	4½	6	9½	8¼	10½	11¼	11¼	12¾	12[illegible]		
								TOTAL SHEETS 1 & 2	1	8	9	20	24	33	30	35	33	35	35	35	90½	297

Payload to Traffic Model Equivalency

Initial effort in the programmatics task included the development of an equivalency between the four representative payloads defined in this study and the Spacelab traffic model. This equivalency is summarized in Table 3-5.

Table 3-5. Spacelab Traffic Model Equivalencies

Study Representative Payload	Traffic Model Payload		Configuration	Launch Schedule 80	81	82	83	84	85	86	87	88	89	90	91
Combined Astronomy	AS-01 SV-1 IR-1	Astrophysics	5 Pallets	0	0	0	1	2	4	4	5	4	4	4	4
	SV-2 SH-3	Solar Terrestrial	5 Pallets						2	2	2	2	2	2	2
	PA-1	Physics and Astronomy	5 Pallets			1	3	3	3	3	3	3	3	3	3
				0	0	1	4	5	9	9	10	9	9	9	9
Life Sciences	LS-09	Life Sciences	Long Module		2	2	2	2	2	2	2	2	2	2	2
ATL-A	AP-06	Solar Terrestrial	SH Mod + 3 Pallets				1	2	2	2	2	2	2	2	2
	ATL-1	Space Tech	SH Mod + 3 Pallets		1	1	2	1	2	1	2	1	2	1	2
	MU	Multi-User Applications	Long Mod + Pallet	1	1	3	3	3	3	2	2	2	2	2	2
	MU		SH Mod + 3 Pallets		1			2	2	3	3	3	3	3	3
	CSP01S COM-1	Non-NASA	Long Mod + Pallet						2	2	3	3	3	3	3
	FSP 01S	Foreign S/L	Long Mod + Pallet						1		1	1	1	1	1
	EON — GPN	ESA	SH Mod + 3 Pallets				1	2	2	2	2	2	2	2	2
				1	3	4	7	10	14	12	15	14	15	15	16
Space Proc.	MU	Multi-User	3 Pallet		1										
	ASN CSN	Foreign S/L	2 Pallet				1		1	1	2	1	2	1	1
	SS	Space Industrialization	Pallet Train		2	2	2	3	3	3	3	4	4	4	4
	SPN-5P	ESA	1 Pallet				1	1	1	1	1	1	1	1	1
	SPN-6P	W. Germany	1 Pallet				3	3	3	2	2	2	2	2	2
					3	2	7	7	8	7	8	8	9	8	8

Buildup Analysis

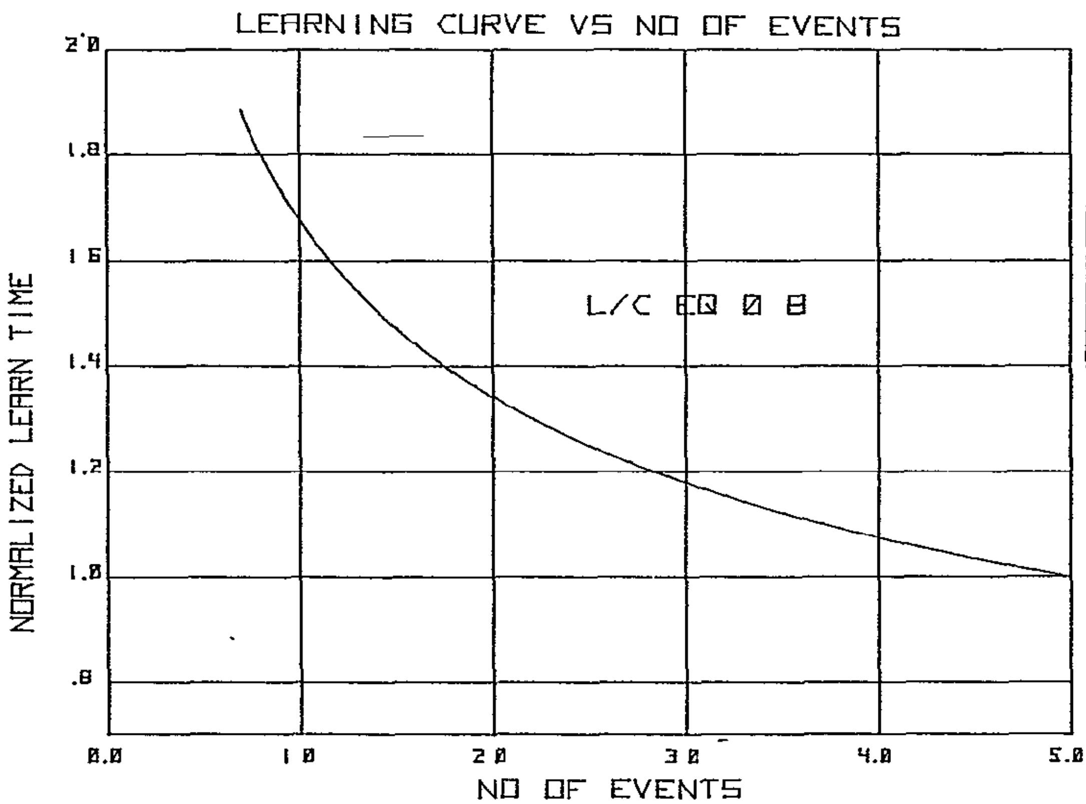
The Spacelab Ground Processing times developed for the study payloads were based on an operational steady-state condition. That is, the payload buildup and task sequences were assumed to be done under normal operating conditions. For example, no provisions were made to accommodate for learning times in the early portion of the flight schedule. Therefore, some period of time must be added to the initial group of payloads that are introduced into the system through any center.

The NASA has provided this study with a learning value of 80 percent with an operational steady-state activity achieved by the fifth mission passing through that center. The 80 percent learning curve is shown in Figure 3-6. The curve illustrates the time-multiple factors for the initial payloads up through the fifth mission at which time all subsequent missions proceed through the ground processing flows based on the operational timelines established in this study.

The actual equations used to determine the learning curve factors is:

$$\text{Learning Curve Factor} = (\text{Learning Curve})^{\left(\frac{\log n}{\log 2}\right)}$$

where n is the number of payloads over which the learning is spread (in this case n = 5).



Flight	Normalized Factors
1	1.679
2	1.341
3	1.178
4	1.074
5	1.000

Figure 3-6. Learning Curve - 80%

The above curve indicates that the ground processing sequence will require approximately 68 percent more time in the buildup sequence for the first payload entering the system at its' particular center. The learning times were computed by the normalizing factors shown in the table in Figure 3-6.

An example of the application of the learning curve is shown in Figure 3-7. The first five missions were taken from the "Schedule Analysis" section and used to show the operation and effect of the application of the learning curve. The first 5 missions are shown in Table 3-6, which includes the type payload, year and day of year of launch.

Table 3-6. Early Missions Subject to Learning Curve

No.	Mission	Year	Launch Day
1	ATL-1	1980	130
2	ATL-2	1981	32
3	Space Processing	1981	65
4	ATL-3	1981	97
5	Life Science	1981	130

The more reasonable method of illustrating the affect of the learning curve was to select a situation which would include the median ground flow times. The selection should also include a lead center activity time butted against the KSC activity time with the additional time of staggering included. Consequently, Option B-1 was selected.

Table 3-7 indicates that the total time including the normalization for learning at both the Lead Center for that particular payload plus the time (normalized) at KSC. Knowing the total time lengths of each payload, scheduling processes can be employed to determine the necessary start time to achieve the scheduled launch date.

Table 3-7. Ground Processing Times Normalized For Learning

Payload or Mission	Staging & Gnd Proc. Time (Days)	Learning X Curve Factor	Lead Ctr [1] = Gnd Proc Time (Days)	KSC Proc Time (Days)	Learning X Curve Factor	KSC [2] = Time Only (Days)	Total Time 1 plus 2	Comments
ATL-1	33.9	1.679	56.9	42	1.679	70.5	127.4	This is the first payload for both the ATL Lead Center and KSC.
ATL-2	33.9	1.341	45.5	42	1.341	56.3	101.8	This is the second payload for both the ATL Lead Center and KSC.
SP-1	31.0	1.679	52.0	36.2	1.178	42.6	94.6	This is the first payload for the SP Lead Center; however, this is the third payload for KSC.
ATL-3	33.9	1.178	39.9	42	1.074	45.1	85.0	This is the third payload for the ATL Lead Center; however, this is the fourth payload for KSC.
LS-1	29.8	1.679	50.0	40.4	1.000	40.4	90.4	This is the first payload for the LS Lead Center; however, the fifth for KSC.

In addition, should potential conflicts appear due to the overlapping of ground processing tasks both that fact and this amount of overlap can be identified. Such an overlap is indicated in Figure 3-7, highlighted by the circle. Once identified, schedule modification by shifting the launch dates of the affected payloads by the overlap may be considered.

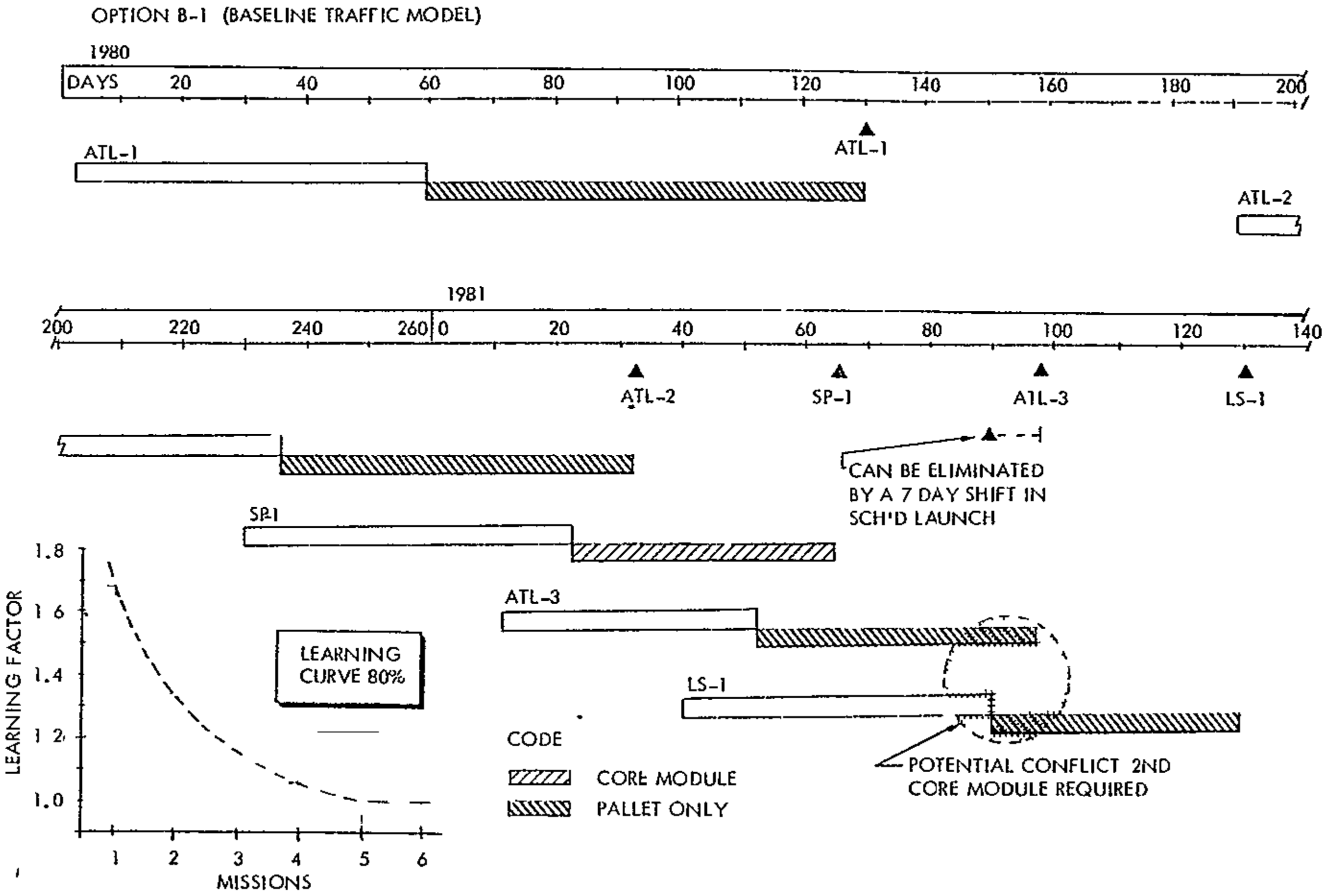


Figure 3-7. Potential Conflict - Overlap of Equipment

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Schedule Analysis

The previous section, Buildup Analysis, indicated that scheduling of payloads can become very critical especially as the number of flights per year increases. As long as the annual launch rate remains low (i.e. less than 4/yr), the ground processing times, relatively short (i.e. less than 60 days) and the launch dates equally spaces (i.e. 1 per quarter) scheduling does not become a problem. However, where launch dates are relatively close and the ground operations time are such that they overlap conflicts arise with insufficient quantities of ground processing equipment.

An example of conflicts in the launch rate and ground processing cycle is shown in Figure 3-8. The example consists of 3 cases. Case A is the ideal situation where 3 flights are evenly spaced through the year. Theoretically one set of ground processing can be used since there is no overlap in either the flight or ground equipment.

Case B indicates the need of at least two sets of ground processing equipment due to the proximity of launch dates. Case C is an example of what a worse case situation might be. The quantity of ground processing would equal the total number of simultaneously overlapping missions. In the case shown (Case C), three complete sets of equipment would be required.

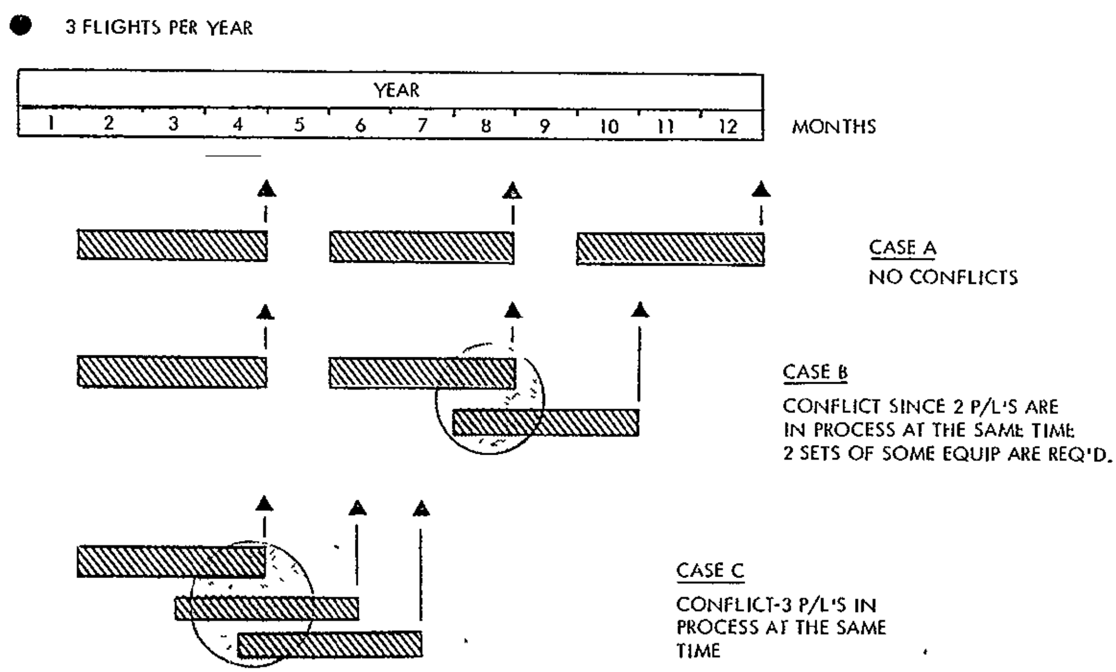

Figure 3-8. Launch Rate (Date) and Ground Processing Cycle Impact

In order to reduce the number of ground processing equipment sets due to the number of conflicting missions, a study model was generated, Table 3-8. This model consists of 297 missions of the four study payloads based on the "560" model discussed supra in the section titled "Payload Equivalencies".

This mission model is established using the following ground rules:

EQUALLY SPACE LAUNCH CENTERS. The objective is to schedule the launch dates equally apart. The typical 5 day-work week was used as the standard. When divided into 52 weeks, a net result of 260 total annual processing days per year. The number of 260 divided by the number of missions per year determines the schedule spacing.

ALTERNATION OF SPACELAB CONFIGURATIONS (where possible). If, in any given year, there are pallet and spacelab module payloads, an attempt should be made to rearrange the schedule permitting an alternating sequence (i.e. pallet, module, pallet, module, etc.).

EVEN DISTRIBUTION WITHIN A GIVEN YEAR. This rule pertains to payloads having the lowest flight rate. For example, if only one such launch per year was scheduled, the subsequent flight would be scheduled 12 months after the first. Similarly, 2 flights per year would be scheduled 6 months apart.

Based on these ground rules, the baseline mission model ("560" model) and the spacelab traffic model equivalencies (Table 3-5), the following study model was prepared, Table 3-8. Since only a single mission was found for the ATL payload, it was scheduled at the mid-point of the year (day 130 of the year 1980). In the year 1981, 8 missions were identified and scheduled approximately 32.5 days appart. In the years 1987, 1989 and 1991, a maximum of 35 missions were identified consequently the schedule between launches averaged 7.4 days.

Table 3-8. Study Mission Model

YEAR	FLIGHT	DAY	PAYLOAD LS	PAYLOAD ATL	PAYLOAD CA	PAYLOAD SP
1980	1	130		X		
Total			-	1	-	-
1981	1	32		X		
	2	65				X
	3	97		X		
	4	130	X			
	5	162				X
	6	195		X		
	7	227				X
	8	260	X			
			2	3	-	3
1982	1	29		X		
	2	58				X
	3	87	X			
	4	116		X		
	5	145			X	
	6	174		X		
	7	203	X			
	8	232				X
	9	260		X		
			2	4	1	2
1983	1	13				X
	2	26		X		
	3	39			X	
	4	52	X			
	5	65				X
	6	78		X		
	7	91				X
	8	104	X			
	9	117			X	
	10	130		X		
	11	143				X
	12	156		X		
	13	169				X
	14	182		X		
	15	195			X	
1983 (Cont'd)	16	208	X			
	17	221				X
	18	234		X		
	19	247				X
	20	260			X	
			2	7	4	7
1984	1	10		X		
	2	21				X
	3	32		X		
	4	43			X	
	5	54		X		
	6	65				X
	7	75		X		
	8	86				X
	9	97		X		
	10	108			X	
	11	119	X			
	12	130				X
	13	140		X		
	14	151			X	
	15	162		X		
	16	173				X
	17	184		X		
	18	195			X	
	19	205		X		
	20	216				X
	21	227		X		
	22	238			X	
	23	249	X			
	24	260				X
			2	10	5	7
1985	1	7		X		
	2	15			X	
	3	23		X		
	4	31				X
	5	39		X		
1985 (Cont'd)	6	48			X	
	7	55		X		
	8	63				X
	9	70		X		
	10	78			X	
	11	86		X		
	12	94				X
	13	102		X		
	14	110			X	
	15	118	X			
	16	126				X
	17	134		X		
	18	141			X	
	19	149		X		
	20	157				X
	21	165		X		
	22	173			X	
	23	181		X		
	24	189				X
	25	197		X		
	26	204			X	
	27	212		X		
	28	220				X
	29	228		X		
	30	236			X	
	31	244	X			
	32	252				X
	33	260			X	
			2	14	9	8
1986	1	8			X	
	2	17		X		
	3	26				X
	4	34		X		
	5	43			X	
	6	52		X		
	7	60				X
	8	69		X		
	9	78			X	
	10	86		X		

Table 3-8. Study Mission Model (Cont'd)

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1986 (Cont'd)	11	95			X	
	12	104		X		
	13	112				X
	14	121	X			
	15	130			X	
	16	138				X
	17	147		X		
	18	156			X	
	19	164		X		
	20	173				X
	21	182		X		
	22	190			X	
	23	199		X		
	24	208				X
	25	216		X		
	26	225			X	
	27	234		X		
	28	242				X
	29	251	X			
	30	260			X	
			2	12	9	7
1987	1	7			X	
	2	14		X		
	3	21				X
	4	29		X		
	5	37			X	
	6	44		X		
	7	51				X
	8	58		X		
	9	66			X	
	10	74		X		
	11	81				X
	12	88		X		
	13	95			X	
	14	103		X		
	15	111				X
	16	118		X		
	17	125			X	

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1987 (Cont'd)	18	132	X			
	19	140			X	
	20	148		X		
	21	155				X
	22	162		X		
	23	169			X	
	24	177		X		
	25	185				X
	26	192		X		
	27	199			X	
	28	206		X		
	29	214				X
	30	222		X		
	31	229			X	
	32	236		X		
	33	243				X
	34	251	X			
	35	259			X	
			2	15	10	8
1988	1	7			X	
	2	15		X		
	3	23				X
	4	31		X		
	5	39			X	
	6	47		X		
	7	55				X
	8	63		X		
	9	70			X	
	10	78		X		
	11	86				X
	12	94		X		
	13	102			X	
	14	110		X		
	15	118				X
	16	126	X			
	17	134			X	
	18	141		X		
	19	149				X
	20	157		X		

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1988 (Cont'd)	21	165			X	
	22	173		X		
	23	181				X
	24	189		X		
	25	197			X	
	26	204		X		
	27	212				X
	28	220		X		
	29	228			X	
	30	236		X		
	31	244				X
	32	252	X			
	33	261			X	
			2	14	9	8
1989	1	7				X
	2	14		X		
	3	21			X	
	4	29		X		
	5	37				X
	6	44		X		
	7	51			X	
	8	58		X		
	9	66				X
	10	74		X		
	11	81			X	
	12	88		X		
	13	95				X
	14	103		X		
	15	111			X	
	16	118	X			
	17	125				X
	18	132		X		
	19	140			X	
	20	148		X		
	21	155				X
	22	162		X		
	23	169			X	
	24	177		X		
	25	185				X

Table 3-8. Study Mission Model (Cont'd)

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1989 (Cont'd)	26	192		X		
	27	199			X	
	28	206		X		
	29	214				X
	30	222		X		
	31	229			X	
	32	236		X		
	33	243				X
	34	251	X			
	35	259			X	
			2	15	9	9
1990	1	7		X		
	2	14			X	
	3	21		X		
	4	28				X
	5	35		X		
	6	42			X	
	7	50		X		
	8	58				X
	9	66		X		
	10	74			X	
	11	82		X		
	12	90				X
	13	98		X		
	14	106			X	
	15	114		X		
	16	122				X
	17	130	X			
	18	137			X	
	19	144		X		
	20	151				X
	21	158		X		
	22	165			X	
	23	172		X		
	24	179				X
	25	188		X		

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1990 (Cont'd)	26	196			X	
	27	204		X		
	28	212				X
	29	220		X		
	30	228			X	
	31	236		X		
	32	244				X
	33	252	X			
	34	260			X	
			2	15	9	8
1991	1	7		X		
	2	14			X	
	3	21		X		
	4	29				X
	5	37		X		
	6	44			X	
	7	51		X		
	8	58				X
	9	66		X		
	10	74			X	
	11	81		X		
	12	88				X
	13	95		X		
	14	103			X	
	15	111		X		
	16	118				X
	17	125	X			
	18	132			X	
	19	140		X		
	20	148				X
	21	155		X		
	22	162			X	
	23	169		X		
	24	177				X
	25	185		X		

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1991 (Cont'd)	26	192			X	
	27	199		X		
	28	206				X
	29	214		X		
	30	222			X	
	31	229		X		
	32	236				X
	33	243		X		
	34	251			X	
	35	259	X			
			2	16	9	8

PERSONNEL REQUIREMENTS - BASELINE TRAFFIC MODEL

Manpower Baseline

The manpower requirements evaluated for this study were in three categories: direct "Hands-on" integration manpower, host Center support and Principal Investigator (PI) support for KSC Operations.

The direct hands-on personnel consist of technicians and engineers involved in the actual installation and checkout tasks associated with Level IV integration. Both engineers and technicians were viewed as being multi-disciplined, i.e., both mechanical and electrical technicians and engineers were considered to be required for the different types of equipment and installations required. In addition to these technicians and engineers, inspection personnel (inspectors) and certain support technicians such as crane operators were included in the estimates. In thinking out the manpower requirements, it has been assumed that all of the "hands-on" personnel were PI employees, other than perhaps the support technicians. It should be noted that, since only "hands-on" personnel were included, manpower requirements for system engineering, mission analysis, design engineering, operations analysis and similar supporting tasks are not included.

The second category of personnel, referred to as Host Center Support, consists of those engineers and technicians provided at either the minicenter, lead center or KSC by the resident organization to provide support for nonresident PI personnel doing the hands-on effort. The magnitude of this support is relatively small, being greatest at KSC and least at the minicenters.

The third category of personnel studied are termed KSC Operations Support personnel, consisting of PI personnel on TDY at KSC in support of Level III and subsequent operations on the payload. These personnel would be few in number, primarily engineers acting as "PI Representatives" and advisors to KSC Operations during these activities. The number of such personnel would be the same for all processing options, since this phase of payload handling and operations is the same regardless of the Level IV option.

As explained in Volume II, the manpower requirements were initially derived from a detailed analysis of the Installation and Test task charts, assigning a number of technicians and engineers to each detailed step for the estimated time required. Then, inspection and support personnel were added, and the total manpower required, in terms of "head count", was smoothed to provide a realistic manpower level. These smoothed manpower levels were applied in the development of the Personnel Cost Analysis Tables. Further rounding of the manpower levels was required in this operation to develop consistent and meaningful data.

In conjunction with developing manpower levels and costs, a very significant part of total personnel costs is the Temporary Duty (TDY) allowance paid to traveling personnel, which varies widely with the processing option. Based on the concept and scenario of travel for hands-on, Host Center Support or KSC Support personnel, a rate of $75 per day was used to determine the magnitude of this expense. In taking the numbers of personnel on TDY and the duration of the TDY assignment, it was assumed that all assignments started

on Mondays, so that any assignments longer than 5 days involved TDY for intervening weedends in addition to working days. Assignments terminating on a Friday would not involve TDY for the following weekend. TDY costs vary with the processing option, being greatest for the KSC (C-X) options, since many PI personnel must travel to KSC to perform Level IV integration tasks.

Personnel Cost Analysis Tables

Using the smoothed manpower levels for each functional block in the Level IV integration process, and the Serial Processing Time for each of these blocks (reported in Volume II), the manpower was expressed in terms of manhours. Multiplying this by $35 per hour for engineers and $30 per hour for technicians, the direct manpower costs for each processing option on each payload were developed. This represents the data in the first part of the Personnel Cost Analysis tables presented herein as Tables 3-9 through 3-12. These tables present the data for each payload in turn, as follows:

Life Science Payload - Table 3-9
Combined Astronomy Payload - Table 3-10
Space Processing Payload - Table 3-11
Advanced Technology Laboratory - Table 3-12

In these tables, the manpower costs are summarized under several headings. "Installation and Experiment Test" represents the activities of Activity Blocks 3, 4, 5 and 6 (as applicable) in installing experiment equipment onto Spacelab racks and pallets and checking installation integrity at the experiment level by test. "Payload Testing, Direct" refers to Activity Blocks 7, 8 and 9 wherein the Spacelab racks and pallets, with experiment equipment installed, are interconnected and tested as a complete payload to verify interfaces made during integration, and to verify checkout software. "Installation and Test Support" refers to personnel at the integration site other than "hands-on" labor, engaged in providing logistic, facility and other types of support to the actual integrating personnel during performance of Activity Blocks 3 through 9. "Level III/II/I and Postflight Support" refers to PI personnel at KSC during these Spacelab/Orbiter operations acting as advisory and support personnel. "Deintegration Direct" and "Deintegration Support" refers to hands-on and supporting personnel, respectively, performing the deintegration of experiment hardware from the Spacelab elements after flight and higher level deintegration - as covered in Activity Block 16.

As can be seen from these tables, the great majority of the personnel costs are Principal Investigator (PI) personnel costs. These data will be carried further strictly in the form of the dollar amounts from these tables.

The TDY Costs in Tables 3-9 through 3-12 is broken down in a similar manner. "Installation and Test Direct" refers to Activity Blocks 3 through 9, combining Installation and Experiment Test with Payload Test, covering TDY expenses for all non-resident PI personnel in both categories. "Level III/II/I and Post Flight Support" was explained previously as manpower, as was "Deintegration Direct". There is no entry for TDY for Deintegration Support, since these personnel are always resident KSC personnel.

Programmatic Manpower Requirements

Since the personnel costs presented and explained in "Personnel Cost Analysis Tables" refer to the costs for a single mission, the process for applying these data to the entire program, as represented by the Baseline Traffic Model, consists of simply multiplying these per-flight totals by the number of flights in a given year to determine the manpower costs for that year. It should be noted that, although some of the manpower associated with a particular flight may be expended in the year prior to the flight year, no attempt has been made to separate these costs. Hence, all manpower costs associated with a flight are charged in the year the flight occurs.

Tables 3-13 through 3-18 presents the total personnel costs, including both manpower and TDY, for all four payloads, on a year-by-year basis for the 1980 to 1991 time span of the Baseline Traffic Model. All amounts are in 1977 dollars. The six tables cover these costs for Options A-1, A-3 (A-2 for Space Processing), B-1, B-4, C-1 and C-4. The payload totals are also shown.

In developing the personnel cost data for the final resource tables and charts, both annual and cumulative, the Manpower and TDY figures were combined and expressed in millions of dollars.

Table 3-9. Personnel Cost - Life Science
(Costs in 1977 $)

Cost Element \ Option	A-1	A3	B1	B4	C1	C4
Manpower						
Instl and Exp Test, Direct (3, 4, 5, 6)	121465	121465	88680	82530	88680	62530
Payload Test, Direct (7, 8, 9)	-	14200	-	9720	-	9720
Instl & Test Support (3 through 9)	-	4760	2135	3342	8540	13370
Level III/II/I and Postflight Support (10, 11, 12, 13, 15)	48000	48000	48000	38400	48000	38400
Deintegration Direct (16)	21900	21900	21900	21900	21900	21900
Deintegration Support (16)	2100	2100	2100	2100	2100	2100
TOTAL MANPOWER	193465	212425	162815	157992	169220	148020
TDY Expense						
Instl & Test Direct (3 through 9)	-	9600	11957	14157	30825	35625
Level III/II/I & Post flight Support	14850	14850	14850	13500	14850	13500
Deintegration Direct Labor	6900	6900	6900	6900	6900	6900
TOTAL TDY	21750	31350	33707	34557	52575	56025
TOTAL PERSONNEL COST	215215	243775	196522	192549	221795	204045

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Table 3-10. Personnel Cost - Combined Astronomy
(Costs in 1977 $)

Cost Element \ Option	A1	A3	B1	B4	C1	C4
Manpower						
Instl and Exp Test, Direct (3, 4, 5, 6)	124870	124870	124870	96860	124870	96860
Payload Test, Direct (7, 8, 9)	-	33460	-	24940	-	24940
Instl & Test Support (3 through 9)	-	5880	7140	6160	14280	12320
Level III/II/I and Postflight Support (10, 11, 12, 13, 15)	25920	25920	25920	25920	25920	25920
Deintegration Direct (16)	13000	13000	13000	13000	13000	13000
Deintegration Support (16)	3120	3120	3120	3120	3120	3120
TOTAL MANPOWER	166910	206250	174050	170000	181190	176160
TDY Expense						
Instl and Test Direct (3 through 9)	6525	18750	12215	22915	48750	45825
Level III/II/I and Postflight Support	9000	9000	9000	9000	9000	9000
Deintegration Direct Labor	4725	4725	4725	4725	4725	4725
TOTAL TDY	20250	32475	25940	36640	62475	59550
TOTAL PERSONNEL COST	187160	238725	199990	206640	243665	235710

Table 3-11. Personnel Cost – Space Processing
(Costs in 1977 $)

Cost Element \ Option	A1	A2	B1	B4	C1	C4
Manpower						
Installation & Exp Test, Direct Labor (3, 4, 5, 6)	84875	86870	84875	86870	84875	86870
Payload Testing, Dir Labor (7, 8, 9)	-	1805	-	1805	-	1805
Instl. & Test Support (3 thru 9)	-	-	5320	5565	10640	11130
Level III/II/I and Postflight Support (11, 12, 13, 15)	22555	22555	22555	22555	22555	22555
Deintegration, Direct (16)	11590	11590	11590	11590	11590	11590
Deintegration Support (16)	-	-	-	-	-	-
TOTAL MANPOWER	119020	122820	124340	128385	129660	133950
TDY Expense						
Instl, and Test, Direct (3 through 9)	7312	7537	14625	15075	29250	30150
Level III/II/I and Postflight Support	8850	8850	8850	8850	8850	8850
Deintegration Direct Labor	4500	4500	4500	4500	4500	4500
TOTAL TDY	20662	20887	27975	28425	42600	43500
TOTAL PERSONNEL COST	139682	143707	152315	156810	172260	177450

Table 3-12. Personnel Cost – ATL
(Costs in 1977 $)

Cost Element \ Option	A1	A3	B1	B4	C1	C4
Manpower						
Instl and Exp. Test, Direct (3, 4, 5, 6)	127890	127890	127890	123400	127890	123400
Payload Testing, Direct (7, 8, 9)	-	25640	-	15000	-	15000
Instl and Test Support (3 through 9)	-	4760	6190	7105	12180	14210
Level III/II/I & Postflight Support (10, 11, 12, 13, 15)	48000	48000	48000	38400	48000	38400
Deintegration Direct (16)	15000	15000	15000	15000	15000	15000
Deintegration Support (16)	3120	3120	3120	3120	3120	3120
TOTAL MANPOWER	194010	224410	200200	202025	206190	209130
TDY Expense						
Instl & Test Direct (3 through 9)	9395	19795	18700	27260	37575	54525
Level III/II/I & Postflight Support	17100	17100	15750	17100	15750	17100
Deintegration Direct Labor	4500	4500	4500	4500	4500	4500
TOTAL TDY	30995	41395	39040	48860	57825	76125
TOTAL PERSONNEL COST	225005	265805	239240	250885	264015	285255

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Table 3-13. BASELINE TRAFFIC MODEL
(1977 $ K) MANPOWER COSTS

OPTION: A-1

	ATL			LIFE SCIENCE			COMB. ASTRONOMY			SP.' PROCESSING				
Yr	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY		
1980	1	194	31	-	-	-	-	-	-	-	-	-	194	31
1981	3	582	93	2	386	44	-	-	-	3	357	63	1,325	200
1982	4	776	124	2	386	44	1	167	20	2	238	42	1,567	230
1983	7	1358	217	2	386	44	4	668	80	7	833	147	3,245	488
1984	10	1940	310	2	386	44	5	835	100	7	833	147	3,994	601
1985	14	2716	434	2	386	44	9	1503	180	8	952	168	5,557	826
1986	12	2328	372	2	386	44	9	1503	180	7	833	147	5,050	743
1987	15	2910	465	2	386	44	10	1670	200	8	952	168	5,918	877
1988	14	2716	434	2	386	44	9	1503	180	8	952	168	5,557	826
1989	15	2910	465	2	386	44	9	1503	180	9	1071	189	5,870	878
1990	15	2910	465	2	386	44	9	1503	180	8	952	168	5,751	857
1991	16	3104	496	2	386	44	9	1503	180	8	952	168	5,945	888
Totals	126	24,444	3,906	22	4,246	484	74	12,358	1,480	75	8,925	1,575	49,973	7,445

Table 3-14. BASELINE TRAFFIC MODEL
(1977 $ K) MANPOWER COSTS

OPTION: A-3

	ATL			LIFE SCIENCE			COMB.' ASTRONOMY			SP. PROCESSING				
Yr	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	224	41	-	-	-	-	-	-	-	-	-	224	41
1981	3	672	123	2	424	62	-	-	-	3	369	63	1,465	248
1982	4	896	164	2	424	62	1	207	32	2	246	42	1,773	300
1983	7	1,568	287	2	424	62	4	828	128	7	861	147	3,681	624
1984	10	2,240	410	2	424	62	5	1035	160	7	861	147	4,560	779
1985	14	3,136	574	2	424	62	9	1863	288	8	984	168	6,407	1092
1986	12	2,688	492	2	424	62	9	1863	288	7	861	147	5,836	989
1987	15	3,360	615	2	424	62	10	2070	320	8	984	168	6,838	1,165
1988	14	3,136	574	2	424	62	9	1863	288	8	984	168	6,407	1,092
1989	15	3,360	615	2	424	62	9	1863	288	9	1107	189	6,754	1,154
1990	15	3,360	615	2	424	62	9	1863	288	8	984	168	6,631	1,133
1991	16	3,584	656	2	424	62	9	1863	288	8	984	168	6,855	1,174
Totals	126	28,224	5,166	22	4,664	682	74	15,318	2,368	75	9,225	1,575	57,431	9,791

FLTS = Flights
M/P = Manpower
TDY = Temporary Duty

Table 3-15. BASELINE TRAFFIC MODEL
(1977 $ K) MANPOWER COSTS

OPTION B-1

	ATL			LIFE SCIENCE			COMB. ASTRONOMY			SP. PROCESSING				
Yr	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	200	39	-	-	-	-	-	-	-	-	-	200	39
1981	3	600	117	2	326	68	-	-	-	3	372	84	1298	269
1982	4	800	156	2	326	68	1	174	26	2	248	56	1548	306
1983	7	1400	273	2	326	68	4	696	104	7	868	196	3290	641
1984	10	2000	390	2	326	68	5	870	130	7	868	196	4064	784
1985	14	2800	546	2	326	68	9	1566	234	8	992	224	5684	1072
1986	12	2400	468	2	326	68	9	1566	234	7	868	196	5160	966
1987	15	3000	585	2	326	68	10	1740	260	8	992	224	6058	1137
1988	14	2800	546	2	326	68	9	1566	234	8	992	224	5684	1072
1989	15	3000	585	2	326	68	9	1566	234	9	1116	252	6008	1139
1990	15	3000	585	2	326	68	9	1566	234	8	992	224	5884	1111
1991	16	3200	624	2	326	68	9	1566	234	8	992	224	6084	1150
TOTAL	126	25,200	4,914	22	3,586	748	74	12,876	1,924	75	9,300	2,100	50,962	9,686

Table 3-16. BASELINE TRAFFIC MODEL
(1977 $ K) MANPOWER COSTS

OPTION B-4

	ATL			LIFE SCIENCE			COMB. ASTRONOMY			SP. PROCESSING				
Yr	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	202	49	-	-	-	-	-	-	-	-	-	202	49
1981	3	606	147	2	316	70	-	-	-	3	384	84	1,306	301
1982	4	808	196	2	316	70	1	170	37	2	256	56	1,550	359
1983	7	1,414	343	2	316	70	4	680	148	7	896	196	3,306	757
1984	10	2,020	490	2	316	70	5	850	185	7	896	196	4,082	941
1985	14	2,828	686	2	316	70	9	1530	333	8	1024	224	5,698	1,313
1986	12	2,424	588	2	316	70	9	1530	333	7	896	196	5,166	1,187
1987	15	3,030	735	2	316	70	10	1700	370	8	1024	224	6,070	1,399
1988	14	2,828	686	2	316	70	9	1530	333	8	1024	224	5,698	1,313
1989	15	3,030	735	2	316	70	9	1530	333	9	1152	252	6,028	1,390
1990	15	3,030	735	2	316	70	9	1530	333	8	1024	224	5,900	1,362
1991	16	3,232	784	2	316	70	9	1530	333	8	1024	224	6,102	1,411
Totals	126	25,452	6,174	22	3,476	770	74	12,580	2,738	75	9,600	2100	51,108	11,782

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Table 3-17. BASELINE TRAFFIC MODEL
(1977 $ K) MANPOWER COSTS
OPTION C-1

OPTION. C-1

	ATL			LIFE SCIENCE			COMBINED ASTRONOMY			SPACE PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	206	58	-	-	-	-	-	-	-	-	-	206	58
1981	3	618	174	2	338	106	-	-	-	3	390	129	1,346	409
1982	4	824	232	2	338	106	1	181	62	2	260	86	1,603	486
1983	7	1,442	406	2	338	106	4	724	248	7	910	301	3,414	1,061
1984	10	2,060	580	2	338	106	5	905	310	7	910	301	4,213	1,297
1985	14	2,884	812	2	338	106	9	1,629	558	8	1,040	344	5,891	1,820
1986	12	2,472	696	2	338	106	9	1,629	558	7	910	301	5,349	1,661
1987	15	3,090	870	2	338	106	10	1,810	620	8	1,040	344	6,278	1,940
1988	14	2,884	812	2	338	106	9	1,629	558	8	1,040	344	5,891	1,820
1989	15	3,090	870	2	338	106	9	1,629	558	9	1,170	387	6,227	1,921
1990	15	3,090	870	2	338	106	9	1,629	558	8	1,040	344	6,097	1,878
1991	16	3,296	928	2	338	106	9	1,629	558	8	1,040	344	6,303	1,936
TOTALS	126	25,956	7,308	22	3,718	1,166	74	13,394	4,588	75	9,750	3,225	52,818	16,287

Table 3-18. BASELINE TRAFFIC MODEL
(1977 $ K) MANPOWER COSTS
OPTION C-4

OPTION C-4

	ATL			LIFE SCIENCE			COMBINED ASTRONOMY			SPACE PROCESSING				
	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	209	76	-	-	-	-	-	-	-	-	-	209	76
1981	3	627	228	2	336	112	-	-	-	3	402	132	1,365	472
1982	4	836	304	2	336	112	1	176	60	2	268	88	1,616	564
1983	7	1,463	532	2	336	112	4	704	240	7	938	308	3,441	1,192
1984	10	2,090	760	2	336	112	5	880	300	7	938	308	4,244	1,480
1985	14	2,926	1,064	2	336	112	9	1,584	540	8	1,072	352	5,918	2,068
1986	12	2,508	912	2	336	112	9	1,584	540	7	938	308	5,366	1,872
1987	15	3,135	1,140	2	336	112	10	1,760	600	8	1,072	352	6,303	2,204
1988	14	2,926	1,064	2	336	112	9	1,584	540	8	1,072	352	5,918	2,068
1989	15	3,135	1,140	2	336	112	9	1,584	540	9	1,206	396	6,261	2,188
1990	15	3,135	1,140	2	336	112	9	1,584	540	8	1,072	396	6,127	2,144
1991	16	3,344	1,216	2	336	112	9	1,584	540	8	1,072	352	6,336	2,220
TOTALS	126	26,334	9,576	22	3,696	1,232	74	13,024	4,440	75	10,050	3,300	53,104	18,548

GSE REQUIREMENTS - BASELINE TRAFFIC MODEL

Introduction

The Ground Support Equipment (GSE) considered in this study was limited to that equipment required to support the installation and checkout of Spacelab equipment during the Level IV Integration task. Equipment of a general purpose nature which would serve for installation/testing of experiment equipment as well as Spacelab equipment, such as multi-purpose sling sets, was included. However, equipment especially designed for use with experiment equipment (furnished by the Principal Investigator) was also assumed to be supplied by the P.I. The rationale for this assumption was that the P.I. would have to develop and build such equipment at his "home location" to accomplish assembly and testing operations at that level, and this equipment should be made available for use in subsequent integration levels for similar tasks.

Because the GSE considered was designed for handling, transportation or testing (checkout) of Space lab equipment, almost all of this equipment was taken from the Spacelab GSE Items Description Document (MSFC 40A99006) Rev. A. A few special items were conceived to support checkout of Spacelab-experiment interfaces and other tasks not effectively supported by the GSE in the referenced document.

In determining the GSE required to support the specific payloads studied, several considerations were made. First of all, it was assumed that only interface verifications would be performed, as opposed to functional or specification testing. In other words, the testing required would only verify that all "copper paths" between experiment equipment and Spacelab equipment interfaces were complete, and would not attempt to verify that the Spacelab or experiment equipment was operating in accordance with its specification requirements. Also, testing performed at an earlier stage would not be repeated, unless it was required for some new reason, such as to verify compatibility between experiments at a payload-level assembly.

Methodology

The determination of what GSE would be required to support a payload as well as how long it would be required was accomplished by the preparation of GSE Utilization charts. A sample chart of this type was presented as Figure 4-1 in Volume II of this work. The procedure for developing such a chart was as follows:

(a) Lay out a timeline at the top, covering, for the payload and processing option in question, the period from the beginning of postflight Level IV Deintegration through Staging, Transportation to the Level IV Integration site, Level IV Integration itself, and Transportation to KSC Level III Integration site. (This was considered the period during which the type of GSE being considered would be utilized.) Lay out a time scale in working days below this functional block timeline.

(b) On a table along the right side, list all items of GSE that would be required for assembling, transporting, servicing, testing, or checkout of experiment equipment, considering the guidelines outlined in Intro. above. For items taken from MSFC 40A99006, list the GSE number from that document. List also the quantity required to support the payload during that period, and the unit cost of each GSE item in accordance with the LaRC price information. GSE items not covered in the MSFC document nor priced by LaRC were priced by estimation based on cost of similar equipment.

(c) Below the timeline (reference (a) above) and alongside the listing for each piece of GSE, draw in solid lines covering the actual time during which the GSE would be in use. This would be the time for positioning/installing/connecting as well as active physical use of the equipment.

(d) Examine the amount of utilization time shown in step (c) in terms of the proportion of total time it occupies. If there are gaps in the utilization of approximately 50% or more of the total timeline, the gap represents time available for possible use by other payloads. Also consider transportation time to get the GSE to the integration site from the GSE depot at KSC, and return it to the depot after use. Using these considerations, place delta symbols at the beginning and end of these periods to define the total involvement time. In the table to the right, enter this total involvement time in working days.

(e) For each GSE line item, calculate the prorated cost of the GSE involvment, using the following formula:

$$\text{Prorated cost} = \frac{\text{Quan.} \times \text{Unit Cost} \times \text{Involvement time}}{250 \ \frac{\text{day}}{\text{yr}} \times 10 \text{ years}^{*}}$$

(f) Repeat the above process for each payload and each processing option.

(g) Total the prorated costs for each payload and option to get the total GSE costs on a per-flight basis.

* Study groundrule that GSE had a 10 year useful life.

This process was followed to derive the total baseline GSE costs per flight as reported in Volume II.

In developing the total involvement time, it is helpful to segregate the GSE used in processing the payload from that used solely for transportation. Processing GSE are those items of GSE used for assembly/disassembly, checkout, handling, and servicing. These items are normally used only during actual Level IV installation and checkout activities. Transportation items, such as pallet support structures, pallet covers, rack handling and shipping fixtures, etc. are used chiefly for transportation, though some (such as the pallet support) may also be used throughout the active integration cycle.

In this study, it was assumed that the transportation GSE was in use and involved for the entire integration period plus the transportation periods as well. The following Figure 3-9 diagrams illustrate this relationship and the resultant significance of the distinction between the two types.

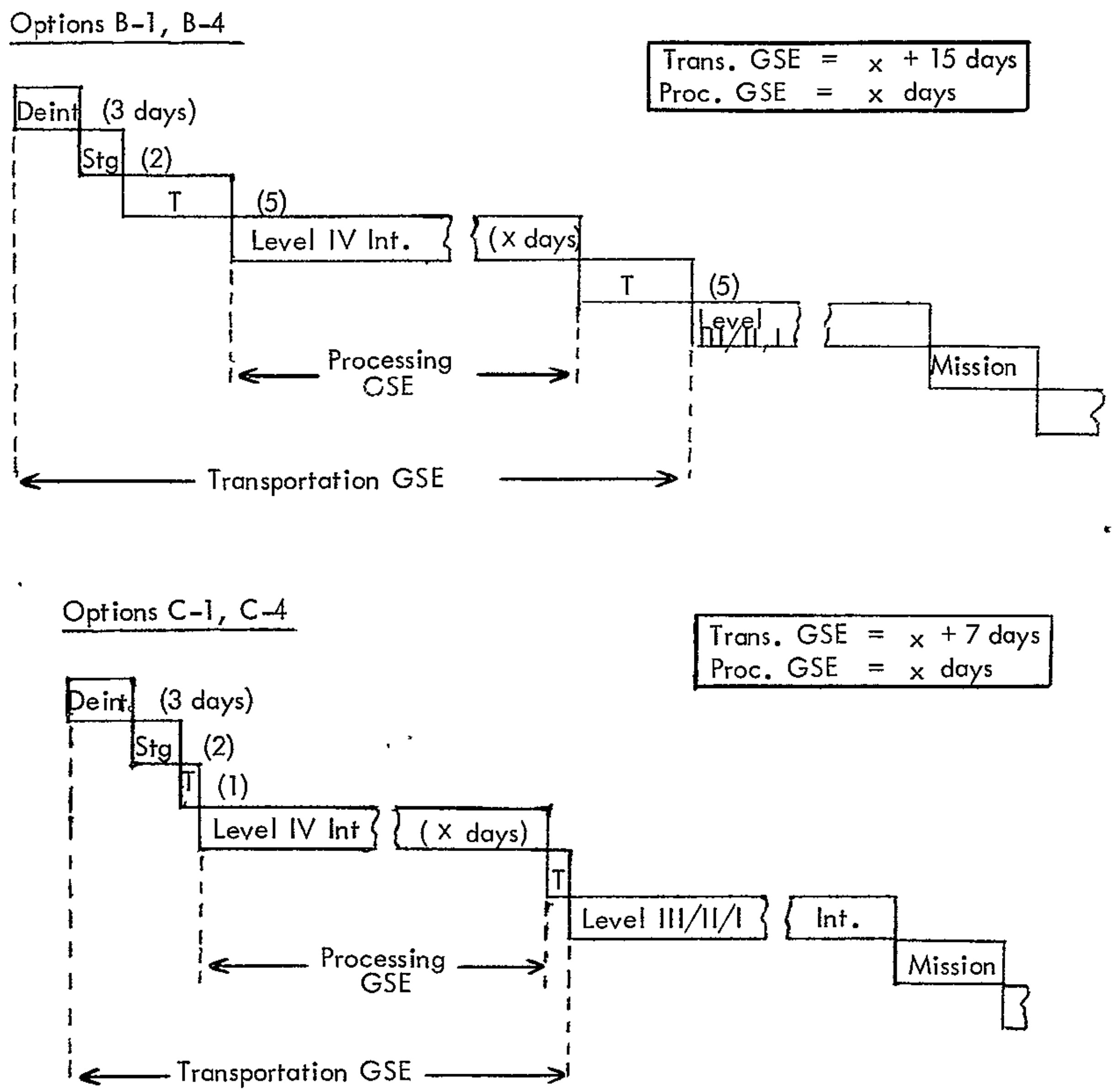

Figure 3-9 GSE Utilization

As can be seen from the above diagrams, the transportation time (labeled T) is the primary factor differentiating the B options (Lead Center) from the C options (KSC), but in both cases there is a significant difference between the involvement time of the Processing GSE and the Transportation GSE. As a result, viewing GSE requirements from a programmatic standpoint, it is evident that more sets of transportation GSE than processing GSE will be required to support any given flight rate/traffic model.

Programmatic GSE Assessment

In establishing the GSE requirements for the baseline per-flight resources, the approach described above in steps (a) through (g) was followed, analyzing the involvement time for each item of GSE separately. In determining GSE requirements for the entire program and its three traffic models, this approach was modified somewhat. The following discussion is limited to Baseline Traffic Model. It was recognized that, in fact, GSE will not really be available for other usage between several usages on one payload cycle. Time will not permit shipment of GSE to another integration site, usage at that site, and then return to the initial site for a second use, without schedule impact. Therefore, in the programmatic GSE assessment, the GSE is assumed to be involved for the entire period; i.e., processing GSE is assumed to be involved for the entire Level IV Integration period (x days in the above diagrams) and transportation GSE is assumed to be involved for the period from start of deintegration through shipping to KSC and start of Level III activity.

To determine GSE requirements for programmatic purposes, the GSE for a given payload is treated as a processing set and a transportation set, as opposed to individual items. Based on the involvement times derived as described above, one of these sets can support a certain flight rate of the given study payload (determined by dividing 250 working days per year by the involvement time of the set of GSE, rounded to the next lower integer). When, according to the traffic model being used, this flight rate is exceeded, a second GSE set must be provided.

EXAMPLE:

Processing GSE set Involvement Time = 45 days

Flight Rate supported by one set = 250 ÷ 45 = 5.55 (rounded to 5)

Year	1980	1981	1982	1983
Flight Rate	3	4	6	12
GSE Sets Needed	1	1	2	3

Using this methodology, the GSE requirements for each year in the Baseline Traffic Model were determined, and therefrom the GSE spending requirements for each year - on the basis that the funds would be expended the year before the year in which the GSE equipment would be needed.

Life Science GSE Requirements

The Life Science payload was studied in terms of GSE requirements, both numbers of GSE sets and spending requirements, in accordance with the above methodology. The analysis was carried out for processing options A-1, A-3, B-1, B-4, C-1, and C-4. In the A-1 and A-3 options, Level IV integration is carried out in eight (8) minicenters at scattered PI sites around the country. Tables 3-19 through 3-26 present the composition and cost of a single processing and transportation set of GSE (designated P and T in the tables) for each of the minicenters. Table 3-27 presents the additional set of GSE, and its costs, required at KSC to support Option A-3.

For Options B-1 and B-4, a similar analysis was carried out, and the GSE sets and costs required for the lead centers are presented in Tables 3-28 and 3-29.

For options C-1 and C-4, composite GSE sets were developed to handle all four payloads at KSC on a shared basis. The composition and cost of these sets are presented in Tables 3-30 and 3-31.

Combined Astronomy GSE Requirements

The Combined Astronomy payload also was studied in terms of GSE requirements, both numbers of sets and spending requirements, in accordance with the same methodology explained above. Options A-1, A-3, B-1, B-4, C-1 and C-4 were examined. In the case of this payload, the distributed concept consists of three mini-centers rather than the eight centers of the Life Science payload. Tables 3-32 through 3-34 present the composition and cost of a single processing and transportation set of GSE (designated P and T in the tables) for each of the three mini-centers, which correspond to the forward, mid and aft pallet complements.

For options B-1 and B-4, a similar analysis was carried out, and the GSE sets and costs required for the lead center are presented in Tables 3-35 and 3-36.

For options C-1 and C-4, composite GSE sets were developed to handle all four payloads at KSC on a shared basis. The composition and cost of these sets are presented in Tables 3-30 and 3-31.

Table 3-37 presents the GSE requirements for sets and items of GSE required at KSC to support payload integration, payload checkout subsequent to experiment level checkout (Option A-3 only).

Table 3-19. Life Science Payload - GSE Requirements Minicenter #1

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	8.0
612048	Rack & Floor Shipping Platform	T	24.0	-	24.0
612049	Rack & Floor Support Braces Kit	T	2.5	-	2.5
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	-
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	-	-
612XXX	Gas Bottles, Supply Unit	P	50.0	-	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			206.0	138.0

Table 3-20. Life Science Payload - GSE Requirements Minicenter #2

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST ($K)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	-
612048	Rack & Floor Shipping Platform	T	24.0	-	24.0
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	0	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612112	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
612XXX	Gas Bottles, Supply Unit	P	50.0	50.0	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			281.0	83.0

P = Processing
T = Transportation

Table 3-21. Life Science Payload - GSE Requirements Minicenter #3

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	-
612043	Rack & Floor Shipping Platform	T	24.0	-	-
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	-
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	-
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	7.0
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	-	-
612XXX	Gas Bottles, Supply Unit	P	50.0	-	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	-	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			126.0	73.0

Table 3-22. Life Science Payload - GSE Requirements Minicenter #4

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
				P	T
612002	Transport Dolly	P3	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	-
612048	Rack & Floor Shipping Platform	T	24.0	-	-
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	-	-
612XXX	Gas Bottles, Supply Unit	P	50.0	-	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	-	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	0	20.0
	TOTALS			126.0	59.0

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Table 3-23. Life Science Payload - GSE Requirements
Minicenter #5

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$) P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	-
612048	Rack & Floor Shipping Platform	T	26.0	-	-
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	-	-
612XXX	Gas Bottles, Supply Unit	P	50.0	-	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	-	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			126.0	59.0

Table 3-24. Life Science Payload - GSE Requirements
Minicenter #6

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOTAL (K$) P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	-
612048	Rack & Floor Shipping Platform	T	24.0	-	-
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	-	-
612XXX	Gas Bottles, Supply Unit	P	50.0	50.0	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			256.0	59.0

Table 3-25. Life Science Payload - GSE Requirements Minicenter #7

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	-
612048	Rack & Floor Shipping Platform	T	24.0	-	-
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Cannister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Cannister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	-	-
612XXX	Gas Bottles, Supply Unit	P	50.0	-	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	-	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			126.0	59.0

Table 3-26. Life Science Payload - GSE Requirements Minicenter #8

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	8.0
612048	Rack & Floor Shipping Platform	T	24.0	-	24.0
612049	Rack & Floor Support Braces Kit	T	2.5	-	2.5
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	-
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	-
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	7.0
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
612XXX	Gas Bottles, Supply Unit	P	50.0	50.0	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			281.0	143.0

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Table 3-27. Life Science Payload - GSE Requirements
KSC GSE Set for Option A-3

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$) P	TOT. COST (K$) T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	-
612047	Rack & Floor Shipping Cover	T	3.0	-	-
612043	Rack & Floor Shipping Platform	T	24.0	-	-
612049	Rack & Floor Support Braces Kit	T	2.5	-	-
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	-
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	-
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	-
612110	Horizontal Sling Kit	T	53.5	-	-
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
612XXX	Gas Bottles, Supply Unit	P	50.0	50.0	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	-	-
613XXX	Transportation Instrumentation	T	20.0	-	-
	TOTALS			281.0	

Table 3-28. Life Science Payload - GSE Requirements
Lead Center GSE Sets
Option B-1

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	8.0
612048	Rack & Floor Shipping Platform	T	24.0	-	24.0
612049	Rack & Floor Support Braces Kit	T	2.5	—	2.5
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	9.0
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	9.0
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	7.0
612071	Active ECS Cart	T	33.0	-	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612114	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
612XXX	Gas Bottles, Supply Unit	P	50.0	50.0	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			308.5	276.5

Table 3-29. Life Science Payload - GSE Requirements
Lead Center GSE Sets
Option B-4

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612047	Rack & Floor Shipping Cover	T	8.0	-	8.0
612048	Rack & Floor Shipping Platform	T	24.0	-	24.0
612049	Rack & Floor Support Braces Kit	T	2.5	-	2.5
612050	Double Rack Handling C/O & Transport Kit	T	9.0	-	-
612065	Single Rack Handling C/O & Transport Kit	T	9.0	-	-
612068	Desiccant Canister, Medium, Double Rack	T	9.0	-	-
612069	Desiccant Canister, Small, Single Rack	T	7.0	-	-
612071	Active ECS Cart	T	33.0	-	33.0
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612115	Cleaning Kit	P	11.5	11.5	-
612XXX	Vacuum Pumpint Unit	P	25.0	25.0	-
612XXX	Gas Bottles, Supply Unit	P	50.0	50.0	-
612XXX	Rack Cooling Unit	P	50.5	50.5	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
613XXX	Operator C/O Console	P	80.0	80.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
613XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			308.5	162.0

Table 3-30. KSC Option Level IV GSE Requirements - Option C-1

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT. COST ($K) P	TOT. COST ($K) T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feed Through Protective Covers	T	3 0	-	⑤ 3 0
612010	Pallet Segment Floor Covers	T	3.5		④ 3.5
612013	Pallet Segment Support	T	47.0		④ 47.0
612040	Optical Alignment Kit	P	6 0	6.0	
612047	Racks & Floor Shipping Cover	T	8.0		8.0
612048	Racks & Floor Transport Platform	T	24.0		24.0
612049	Racks & Floor Support Braces	T	2 5		② 2.5
612050	Double Rack Handling & Transport Kit	T	9.0		⑤ 9.0
612059	Pallet Cover	T	12.5		⑤ 12.5
612060A	Pallet Platform, Single	T	24 0		③ 24.0
612060B	Pallet Platform, 2-Train	T	48 0		48.0
612065	Single Rack Handling & Transport Kit	T	9.0		② 9 0
612067	Desiccant Cannister - Large	T	11.5		⑥ 11.5
612068	Desiccant Cannister - Medium	T	9.0		④ 9.0
612069	Desiccant Cannister - Small	T	7 0		④ 7.0
612071	Active Environ. Control Cart	T	33 0		33.0
612080	Portable Leak Detector Unit	P	2.5	2.5	
612084	Freon Servicer	P	25.0	25.0	
612086	Freon Leak Detector	P	1 0	1.0	
612106	Road Tiedown Kit	T	10.5		⑤ 10.5
612110	Horizontal Sling Kit	T	53.5		53 5
612113	Trunnion Holding Fittings	T	1 0		④ 1 0
612114	Cleaning Kit	P	11.5	11.5	
612115	Refrigeration Unit	P	101 0	101.0	
612XXX	Vacuum Pumping Unit	P	25.0	25.0	
612XXX	Rack Cooling Unit	P	50.5	50.5	
612XXX	Gas Bottle Supply Unit	P	50.0	50.0	
612XXX	Operators Console	P	80.0	80.0	
613XXX	Grounding/Bonding Tester	P	31.0	31.0	
614022	Desiccant Drying Oven	P	27 5	27.5	
614XXX	Transportation Instrumentation	T	20 0		② 20.0
612XXX	PSS Panel Rack	P	1.0	1.0	
612XXX	Purge Cart GN_2	P	50.0	50 0	
	Totals			495.0	832 5

○ = Quantity of Items

Table 3-31. KSC Option Level IV GSE Requirements - Option C-4

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT. COST (K$) P	TOT. COST (K$) T
612002	Transport Dolly	P	33.0	33.0	
612006	Vertical Sling Kit	T	10.5		10.5
612008	Feed Through Protective Covers	T	3 0		⑤ 3.0
612010	Pallet Segment Floor Covers	T	3 5		⑤ 3.5
612013	Pallet Segment Support	T	47.0		④ 47.0
612040	Optical Alignment Kit	P	6.0	6 0	
612047	Racks & Floor Shipping Cover	T	8.0		8 0
612048	Racks & Floor Transportation Platform	T	24.0		24.0
612049	Racks & Floor Support Braces	T	2.5		2.5
612050	Double Rack Handling & Transport Kit	T	9 0		
612059	Pallet Cover	T	12.5		⑤ 12 5
612060A	Pallet Platform, Single	T	24.0		③ 24.0
612060B	Pallet Platform, 2-Train	T	48 0		48.0
612065	Single Rack Handling & Transport Kit	T	9.0		
612067	Desiccant Cannister - Large	T	11.5		⑥ 11.5
612068	Desiccant Cannister - Medium	T	9.0		
612069	Desiccant Cannister - Small	T	7.0		
612071	Active Environ Control Cart	T	33.0		33.0
612080	Portable Leak Detector Unit	P	2 5	2.5	
612084	Freon Servicer	P	25 0	25.0	
612086	Freon Leak Detector	P	1.0	1.0	
612106	Road Tiedown Kit	T	10 5		⑤ 10 5
612110	Horizontal Sling Kit	T	53.5		53.5
612113	Trunnion Holding Fittings	T	1.0		④ 1.0
612114	Cleaning Kit	P	11 5	11.5	
612115	Refrigeration Unit	P	101 0	101.0	
612XXX	Vacuum Pumping Unit	P	25 0	25.0	
612XXX	Rack Cooling Unit	P	50.5	50.5	
612XXX	Gas Bottle Supply Unit	P	50.0	50.0	
612XXX	Operators Console	P	80.0	80.0	
613039	Grounding/Bonding Tester	P	31.0	31.0	
614022	Desiccant Drying Oven	P	27.5	27.5	
614XXX	Transportation Instrumentation	T	20 0		③ 20.0
612XXX	PSS Panel Rack	P	1.0	1 0	
612XXX	Purge Cart GN_2	P	50 0	50.0	
	Totals			495.0	705.0

○ = Quantity of Items

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Space Division

Table 3-32. Combined Astronomy-GSE Requirements Options A-1, A-3, Minicenter #1 (Forward Complement)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (SK)	TOT COST (KS)	
				P	T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feedthrough Protective Covers Kit	T	2.0	-	3 0
612010	Pallet Segment Floor Covers	T	3.5	-	3.5
612013A	Pallet Segment Support-Single Pallet	T	47.0	-	47.0
612013B	Pallet Segment Support-2 Train Pallet	T	47.0	-	-
612040	Optical Alignment Kit	P	6.0	6.0	-
612059	Pallet Cover	T	12.5	-	12.5
612060A	Pallet Platform-Single Pallet	T	24.0	-	24.0
612060B	Pallet Platform-2 Train Configuration	T	48.0	-	-
612067	Desiccant Cannister - Large	T	11.5	-	11.5
612071	Active Envir. Control Cart	T	33.0	-	33.0
612084	Freon Servicer	P	25.0	25.0	-
612086	Freon Leak Detector	P	1 0	1.0	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612113	Trunnion Holding Fittings	T	1.0	-	1.0
612114	Cleaning Kit	P	11.5	11.5	-
612115	Refrigeration Unit	P	101.1	101.0	-
612XXX	Operators Console	P	80.0	80.0	-
612XXX	Purge Cart GN2	P	50.0	50.0	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
614XXX	Rack Simulated AFO	P	1.0	1.0	-
614XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			392.0	236.5

Table 3-33. Combined Astronomy-GSE Requirements Options A-1, A-3, Minicenter #2 (Mid-Complement)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (KS)	TOT.COST (KS)	
				P	T
612002	Transport Dolly	P	33.0	-	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feedthrough Protective Covers Kit	T	3.0	-	3.0
612010	Pallet Segment Floor Covers	T	3.5	-	3 5
612013A	Pallet Segment Support-Single Pallet	T	47.0	-	47.0
612013B	Pallet Segment Support-2 Train Pallet	T	47 0	-	47.0
612040	Optical Alignment Kit	P	6.0	6.0	-
612059	Pallet Cover	T	12.5	-	12.5
612060A	Pallet Platform-Single Pallet	T	24.0	-	24.0
612060B	Pallet Platform-2 Train Configuration	T	48.0	-	48.0
612067	Desiccant Cannister - Large	T	11.5	-	11.5
612071	Active Envir. Control Cart	T	33.0	-	33.0
612084	Freon Servicer	P	25.0	25.0	-
612086	Freon Leak Detector	P	1.0	1.0	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612113	Trunnion Holding Fittings	T	1.0	-	1.0
612114	Cleaning Kit	P	11.5	11.5	-
612115	Refrigeration Unit	P	101.0	101.0	-
612XXX	Operators Console	P	80.0	80.0	-
612XXX	Purge Cart CN2	P	50.0	50.0	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
613039	Grounding/Bonding Tester	P	31 0	31.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
614XXX	Rack Simulated AFD	P	1.0	1.0	-
614XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			359.0	458.0

Table 3-34. Combined Astronomy-GSE Requirements
Options A-1, A-3, Minicenter #3 (Aft Complement)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$) P	TOT. COST (K$) T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feedthrough Protective Covers Kit	T	3.0	-	3.0
612010	Pallet Segment Floor Covers	T	3.5	-	3.5
612013A	Pallet Segment Support-Single Pallet	T	47.0	-	47.0
612013B	Pallet Segment Support-2 Train Pallet	T	47.0	-	-
612040	Optical Alignment Kit	P	6.0	6.0	-
612059	Pallet Cover	T	12.5	-	12.5
612060A	Pallet Platform - Single Pallet	T	24.0	-	24 0
612060B	Pallet Platform - 2 Train Configuration	T	48.0	-	-
612067	Desiccant Cannister - Large	T	11.5	-	11.5
612071	Active Envir. Control Cart	T	33.0	-	33.0
612084	Freon Servicer	P	25.0	25.0	-
612086	Freon Leak Detector	P	1.0	1.0	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	-
612113	Trunnion Holding Fittings	T	1.0	-	1.0
612114	Cleaning Kit	P	11.5	11.5	-
612115	Refrigeration Unit	P	101.0	101.0	-
612XXX	Operators Console	P	80.0	80.0	-
612XXX	Purge Cart GN2	P	50.0	50.0	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
614XXX	Rack Simulated AFD	P	1.0	1.0	-
614XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			392.0	179.5

Table 3-35. Combined Astronomy-GSE Requirements
Option B-1

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$) P	TOT. COST (K$) T
612002	Transport Dolly	P	33.0	33.0	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feedthrough Protective Covers Kit	T	3.0	-	3.0
612010	Pallet Segment Floor Covers	T	3.5	-	3.5
612013A	Pallet Segment Support-Single Pallet	T	47.0	-	47.0
612013B	Pallet Segment Support-2 Train Pallet	T	47.0	-	47.0
612040	Optical Alignment Kit	P	6.0	6.0	-
612059	Pallet Cover	T	12.5	-	12.5
612060A	Pallet Platform-Single Pallet	T	24.0	-	24.0
612060B	Pallet Platform-2 Train Configuration	T	48.0	-	48 0
612067	Desiccant Cannister-Large	T	11.5	-	11.5
612071	Active Envir. Control Cart	T	33.0	-	33.0
612084	Freon Servicer	P	25.0	25.0	-
612086	Freon Leak Detector	P	1.0	1.0	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612113	Trunnion Holding Fittings	T	1.0	-	1.0
612114	Cleaning Kit	P	11.5	11.5	-
612115	Refrigeration Unit	P	101.0	101.0	-
612XXX	Operators Console	P	80.0	80.0	-
612XXX	Purge Cart GN2	P	50.0	50.0	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
614XXX	Rack Simulated AFD	P	1.0	1.0	-
614XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			392.0	650.5

Table 3-36. Combined Astronomy-GSE Requirements
Option B-4

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$) P	TOT. COST (K$) T
612002	Transport Dolly	P	33.0	-	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feedthrough Protective Covers Kit	T	3.0	-	3.0
612010	Pallet Segment Floor Covers	T	3.5	-	3.5
612013A	Pallet Segment Support-Single Pallet	T	47.0	-	47.0
612013B	Pallet Segment Support-2 Train Pallet	T	47.0	-	47.0
612040	Optical Alignment Kit	P	6 0	6.0	-
612059	Pallet Cover	T	12.5	-	12.5
612060A	Pallet Platform-Single Pallet	T	24.0	-	24.0
612060B	Pallet Platform-2 Train Configuration	T	48.0	-	48.0
612067	Desiccant Cannister-Large	T	11.5	-	11.5
612071	Active Envir. Control Cart	T	33.0	-	33.0
612084	Freon Servicer	P	25.0	25.0	-
612086	Freon Leak Detector	P	1.0	1.0	-
612106	Road Tiedown Kit	T	10.5	-	10.5
612110	Horizontal Sling Kit	T	53.5	-	53.5
612113	Trunnion Holding Fittings	T	1.0	-	1.0
612114	Cleaning Kit	P	11.5	11.5	-
612115	Refrigeration Unit	P	101.0	101.0	—
612XXX	Operators Console	P	80.0	80.0	-
612XXX	Purge Cart GN2	P	50.0	50.0	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
614022	Desiccant Drying Oven	P	27.5	27.5	-
614XXX	Rack Simulated AFD	P	1.0	1.0	-
614XXX	Transportation Instrumentation	T	20.0	-	20.0
	TOTALS			359.0	650.5

Table 3-37. Combined Astronomy-GSE Requirements
Payload Integration and Deintegration (KSC)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST (K$)	TOT. COST (K$) P	TOT. COST (K$) T
612002	Transport Dolly	P	33.0	-	-
612006	Vertical Sling Kit	T	10.5	-	10.5
612008	Feedthrough Protective Covers Kit	T	3.0	-	-
612010	Pallet Segment Floor Covers	T	3.5	-	-
612013A	Pallet Segment Support - Single Pallet	T	47.0	-	-
612013B	Pallet Segment Support - 2 Train Pallet	T	47.0	-	-
612040	Optical Alignment Kit	P	6.0	6.0	-
612059	Pallet Cover	T	12.5	-	-
612060A	Pallet Platform - Single Pallet	T	24.0	-	-
612060B	Pallet Platform - 2 Train Configuration	T	48.0	-	-
612067	Desiccant Cannister - Large	T	11.5	-	-
612071	Active Envir. Control Cart	T	33.0	-	33.0
612084	Freon Servicer	P	25.0	25.0	-
612086	Freon Leak Detector	P	1.0	1.0	-
612106	Road Tiedown Kit	T	10.5	-	-
612110	Horizontal Sling Kit	T	53.5	-	53.5
6112113	Trunnion Holding Fittings	T	1.0	-	1.0
612114	Cleaning Kit	P	11.5	11.5	-
612115	Refrigeration Unit	P	101.0	101.0	-
612XXX	Operators Console	P	80.0	80.0	-
612XXX	Purge Cart GN2	P	50.0	50.0	-
612XXX	Vacuum Pumping Unit	P	25.0	25.0	-
613039	Grounding/Bonding Tester	P	31.0	31.0	-
614022	Desiccant Drying Oven	P	27.5	-	-
614XXX	Rack Simulated AFD	P	11.0	1.0	-
614XXX	Transportation Instrumentation	T	20.0	-	-
	TOTALS			331.5	101.0

Space Processing GSE Requirements

The Space Processing payload, consisting of only one pallet, was similarly studied to determine GSE requirements, in terms of both GSE set composition, and set cost, treating the GSE set as transportation and processing subsets. The same methodology as explained above was used, and in this case, the options were A-1, A-2, B-1, B-4, C-1 and C-4. Option A-2 was substituted for A-3 in this case because Option A-3 simply is not feasible - functional Block 10 cannot be performed on a one-pallet payload. Another variation is that there are no minicenters in the usual sense, because with only one Spacelab element involved, the effort cannot be subdivided further. Hence, the approaches for options A-1 and A-2 actually represent a lead center type activity located at one of the PI locations. Because of this, the GSE requirements are the same for all options except for additional GSE required at KSC to support additional testing in Option A-2.

Table 3-38 presents the composition and cost of a single set of transportation and processing GSE (designated by the headings T and P respectively) for processing options A-1, A-2, B-1 and B-4 at the integration site. Table 3-39 presents the composition and cost for additional GSE set required at KSC in support of the additional testing in Option A-2. For options C-1 and C-4, composite GSE sets were developed to handle <u>all four</u> payloads at KSC on a shared basis. The composition and cost of these sets are presented in Tables 3-30 and 3-31 .

Table 3-38. Space Processing GSE Requirements (Options A-1, A-2, B-1 and B-4)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOTAL COST ($K) P	TOTAL COST ($K) T
612006	Vertical Sling	T	10.5	--	10.5
612008	Feed Through Covers	T	3.0	--	3.0
612010	Pallet Segment Floor Covers	T	3.5	--	3.5
612013	Pallet Segment Support	T	47.0	--	47.0
612058	Pallet Cover	T	12.5	--	12.5
612060	Pallet Platform	T	24.0	--	24.0
612067	Large Desiccant Canister	T	11.5	--	11.5
612071	Active ECS Cart	T	33.0	--	33.0
612080	Portable Leak Detector	P	2.5	2.5	--
612084	Freon Servicer	P	25.0	25.0	--
612086	Freon Leak Detector	P	1.0	1.0	--
612106	Road Tiedown Kit	T	10.5	--	10.5
612110	Horizontal Sling	T	53.5	--	53.5
612113	Trunnion Handling Fittings	T	1.0	--	④ 1.0
612114	Cleaning Kit	P	11.5	11.5	--
612115	Refrigeration Unit	P	101.0	101.0	--
612XXX	Operators Console	P	80.0	80.0	--
613039	Grounding/Bonding Tester	P	31.0	31.0	--
614022	Desiccant Drying Oven	P	27.5	27.5	--
614XXX	Transportation Instrumentation	T	20.0	--	20.0
614XXX	PSS Panel Rack	P	1.0	1.0	--
	Total			280.5	233.0
	O = Quantity of Items				

Table 3-39. Space Processing GSE Requirements (KSC Option A-3)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOTAL COST ($K) P	TOTAL COST ($K) T
612006	Vertical Sling	T	10.5	--	--
612008	Feed Through Covers	T	3.0	--	--
612010	Pallet Segment Floor Covers	T	3.5	--	--
612013	Pallet Segment Support	T	47.0	--	--
612058	Pallet Cover	T	12.5	--	--
612060	Pallet Platform	T	24.0	--	--
612067	Large Desiccant Canister	T	11.5	--	--
612071	Active ECS Cart	T	33.0	--	33.0
612080	Portable Leak Detector	P	2.5	2.5	--
612084	Freon Servicer	P	25.0	25.0	--
612086	Freon Leak Detector	P	1.0	1.0	--
612106	Road Tiedown Kit	T	10.5	--	--
612110	Horizontal Sling	T	53.5	--	53.5
612113	Trunnion Handling Fittings	T	1.0	--	④ 1.0
612114	Cleaning Kit	P	11.5	11.5	--
612115	Refrigeration Unit	P	101.0	101.0	--
612XXX	Operators Console	P	80.0	80.0	--
613039	Grounding/Bonding Tester	P	31.0	31.0	--
614022	Desiccant Drying Oven	P	27.5	--	--
614XXX	Transportation Instrumentation	T	20.0	--	--
614XXX	PSS Panel Rack	P	1.0	1.0	--
	Total			253.0	90.5
	O = Quantity of Items				

Advanced Technology Laboratory - GSE Requirements

The ATL payload, which consists of a short inhabited module and two pallets, was studied to determine GSE requirements in the same manner as the other three payloads. The composition and cost of both processing and transportation GSE, constituting a GSE set, was determined using the same methodology as previously described in the section entitled "Methodology". As before, the options studied were A-1, A-3, B-1, B-4, C-1 and C-4. This payload, like the Combined Astronomy payload, is divided into three mini-centers for Options A-1 and A-3.

The GSE requirements for options A-1 and A-3, minicenters 1, 2, and 3 are presented in Tables 3-40 through 3-42. Table 3-43 covers additional GSE requirements at KSC to support additional Level IV checkout tasks there for Option A-3 only.

Tables 3-44 and 3-45 present the lead center GSE requirements, representing processing options B-1 and B-4.

For options C-1 and C-4, composite GSE sets were developed to handle all four payloads at KSC on a shared basis. The composition and cost of these sets are presented in Tables 3-30 and 3-31 .

Table 3-40. ATL GSE Requirements (Minicenter #1 Options A-1 and A-3)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT.COST ($K) P	TOT.COST ($K) T
612002	TRANSPORT DOLLY	P	33.0	-	-
612006	VERTICAL SLING KIT	T	10.5	-	10.5
612008	FEED-THROUGH PROTECTIVE COVERS	T	3.0	-	3.0
612010	PALLET SEGMENT FLOOR COVERS	P	3.5	3.5	-
612013	PALLET SEGMENT SUPPORT	T	47.0	-	47.0
612040	OPTICAL ALIGNMENT KIT	P	6.0	6.0	-
612047	RACKS & FLOOR SHIPPING COVER	T	8.0		8.0
612048	RACKS & FLOOR TRANSPORT PLATFORM	T	24.0		24.0
612049	RACKS & FLOOR SUPPORT BRACES	T	2.5	-	2.5
612050	DOUBLE RACK HANDLING & TRANSPORT KIT	T	9.0		-
612059	PALLET COVER	T	12.5	-	12.5
612060	PALLET PLATFORM	T	24.0	-	24.0
612067	DESICCANT CANISTER - LARGE	T	11.5	-	11.5
612068	DESICCANT CANISTER - MEDIUM	T	9.0	-	9.0
612071	ACTIVE ENVIRONMENT CONTROL CART	T	33.0	-	33.0
612080	PORTABLE LEAK DETECTOR UNIT	P	2.5	2.5	-
612084	FREON SERVICER	P	25 0	25.0	-
612086	FREON LEAK DETECTOR	P	1.0	1.0	-
612106	ROAD TIEDOWN KIT	T	10.5	-	10.5
612110	HORIZONTAL SLING KIT	T	53.5	-	53.5
612113	TRUNNION HOLDING FITTINGS	T	1.0	-	4 1 0
612114	CLEANING KIT	P	11.5	11.5	-
612115	REFRIGERATION UNIT	P	101.0	101.0	-
612XXX	RACK COOLING UNIT	P	50.5	50.5	-
612XXX	OPERATORS CONSOLE	P	80 0	80.0	-
613039	GROUNDING/BONDING TESTER	P	31.0	31.0	-
614022	DESICCANT DRYING OVEN	P	27.5	-	-
614XXX	TRANSPORTATION INSTRUMENTATION	T	20.0	-	20.0
	TOTALS			312 0	273.0
	O = Quantity of Items				

Table 3-41. ATL GSE Requirements (Minicenter #2 Options A-1 and A-3)

END ITEM NO	DESCRIPTION	P/T	UNIT COST ($K)	TOT.COST ($K) P	TOT.COST ($K) T
612002	TRANSPORT DOLLY	P	33.0	33.0	
612006	VERTICAL SLING KIT	T	10.5		10.5
612008	FEED-THROUGH PROTECTIVE COVERS	T	3.0		
612010	PALLET SEGMENT FLOOR COVERS	P	3.5		
612013	PALLET SEGMENT SUPPORT	T	47.0		
612040	OPTICAL ALIGNMENT KIT	P	6.0		
612047	RACKS & FLOOR SHIPPING COVER	T	8.0		
612048	RACKS & FLOOR TRANSPORT PLATFORM	T	24.0		
612049	RACKS & FLOOR SUPPORT BRACES	T	2.5		
612050	DOUBLE RACK HANDLING & TRANSPORT KIT	T	9.0		9.0
612059	PALLET COVER	T	12.5		
612060	PALLET PLATFORM	T	24.0		
612067	DESICCANT CANISTER - LARGE	T	11.5		
612068	DESICCANT CANISTER - MEDIUM	T	9.0		9.0
612071	ACTIVE ENVIRONMENT CONTROL CART	T	33.0		
612080	PORTABLE LEAK DETECTOR UNIT	P	2.5	2.5	
612084	FREON SERVICER	P	25.0		
612086	FREON LEAK DETECTOR	P	1.0		
612106	ROAD TIEDOWN KIT	T	10.5		10.5
612110	HORIZONTAL SLING KIT	T	53.5		
612113	TRUNNION HOLDING FITTINGS	T	1.0		
612114	CLEANING KIT	P	11.5	11.5	
612115	REFRIGERATION UNIT	P	101.0		
612XXX	RACK COOLING UNIT	P	50.5	50.5	
612XXX	OPERATORS CONSOLE	P	80.0		
613039	GROUNDING/BONDING TESTER	P	31.0	31 0	
614022	DESICCANT DRYING OVEN	P	27.5		
614XXX	TRANSPORTATION INSTRUMENTATION	T	20.0		20.0
	TOTALS			128.5	59.0

Table 3-42. ATL GSE Requirements
(Minicenter #3 Options A-1 and A-3)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT. COST ($K) P	TOT. COST ($K) T
612002	TRANSPORT DOLLY	P	33.0	33.0	
612006	VERTICAL SLING KIT	T	10.5		
612008	FEED-THROUGH PROTECTIVE COVERS	T	3.0		
612010	PALLET SEGMENT FLOOR COVERS	P	3.5		
612013	PALLET SEGMENT SUPPORT	T	47.0		
612040	OPTICAL ALIGNMENT KIT	P	6.0	6.0	
612047	RACKS & FLOOR SHIPPING COVER	T	8.0		
612048	RACKS & FLOOR TRANSPORT PLATFORM	T	24.0		
612049	RACKS & FLOOR SUPPORT BRACES	T	2.5		
612050	DOUBLE RACK HANDLING & TRANSPORT KIT	T	9.0		
612059	PALLET COVER	T	12.5		
612060	PALLET PLATFORM	T	24.0		
612067	DESICCANT CANISTER - LARGE	T	11.5		
612068	DESICCANT CANISTER - MEDIUM	T	9.0		
612071	ACTIVE ENVIRONMENT CONTROL CART	T	33.0		
612080	PORTABLE LEAK DETECTOR UNIT	P	2.5	2.5	
612084	FREON SERVICER	P	25.0	25.0	
612086	FREON LEAK DETECTOR	P	1.0	1.0	
612106	ROAD TIEDOWN KIT	T	10.5		
612110	HORIZONTAL SLING KIT	T	53.5		
612113	TRUNNION HOLDING FITTINGS	T	1.0		
612114	CLEANING KIT	P	11.5	11.5	
612115	REFRIGERATION UNIT	P	101.0	101.0	
612XXX	RACK COOLING UNIT	P	50.5	50.5	
612XXX	OPERATORS CONSOLE	P	80.0	80.0	
613039	GROUNDING/BONDING TESTER	P	31.0	31.0	
614022	DESICCANT DRYING OVEN	P	27.5		
614XXX	TRANSPORTATION INSTRUMENTATION	T	20.0		
	TOTALS			341.5	0

Table 3-43. ATL GSE Requirements
(KSC Integration Requirements Option A-3)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT. COST ($K) P	TOT. COST ($K) T
612002	TRANSPORT DOLLY	P	33.0	33.0	
612006	VERTICAL SLING KIT	T	10.5		10.5
612008	FEED-THROUGH PROTECTIVE COVERS	T	3.0		3.0
612010	PALLET SEGMENT FLOOR COVERS	P	3.5		3.5
612013	PALLET SEGMENT SUPPORT	T	47.0		47.0
612040	OPTICAL ALIGNMENT KIT	P	6.0	6.0	
612047	RACKS & FLOOR SHIPPING COVER	T	8.0		
612048	RACKS & FLOOR TRANSPORT PLATFORM	T	24.0		
612049	RACKS & FLOOR SUPPORT BRACES	T	2.5		
612050	DOUBLE RACK HANDLING & TRANSPORT KIT	T	9.0		9.0
612059	PALLET COVER	T	12.5		12.5
612060	PALLET PLATFORM	T	24.0		24.0
612067	DESICCANT CANISTER - LARGE	T	11.5		11.5
612068	DESICCANT CANISTER - MEDIUM	T	9.0		9.0
612071	ACTIVE ENVIRONMENT CONTROL CART	T	33.0		33.0
612080	PORTABLE LEAK DETECTOR UNIT	P	2.5	2.5	
612084	FREON SERVICER	P	25.0	25.0	
612086	FREON LEAK DETECTOR	P	1.0	1.0	
612106	ROAD TIEDOWN KIT	T	10.5		10.5
612110	HORIZONTAL SLING KIT	T	53.5		53.5
612113	TRUNNION HOLDING FITTINGS	T	1.0		⑧1.0
612114	CLEANING KIT	P	11.5	11.5	
612115	REFRIGERATION UNIT	P	101.0	101.0	
612XXX	RACK COOLING UNIT	P	50.5	50.5	
612XXX	OPERATORS CONSOLE	P	80.0	80.0	
613039	GROUNDING/BONDING TESTER	P	31.0	31.0	
614022	DESICCANT DRYING OVEN	P	27.5		
614XXX	TRANSPORTATION INSTRUMENTATION	T	20.0		20.0
	TOTALS			341.5	251.0

O = Quantity of Items

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Table 3-44. ATL GSE Requirements (Option B-1)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT. COST ($K) P	TOT. COST ($K) T
612002	TRANSPORT DOLLY	P	33.0	33.0	
612006	VERTICAL SLING KIT	T	10.5		10.5
612008	FEED-THROUGH PROTECTIVE COVERS	T	3.0		3.0
612010	PALLET SEGMENT FLOOR COVERS	P	3.5		3.5
612013	PALLET SEGMENT SUPPORT	T	47.0		47.0
612040	OPTICAL ALIGNMENT KIT	P	6.0	6.0	
612047	RACKS & FLOOR SHIPPING COVER	T	8.0		8.0
612048	RACKS & FLOOR TRANSPORT PLATFORM	T	24.0		24.0
612049	RACKS & FLOOR SUPPORT BRACES	T	2.5		2.5
612050	DOUBLE RACK HANDLING & TRANSPORT KIT	T	9.0		① 9.0
612059	PALLET COVER	T	12.5		② 12.5
612060	PALLET PLATFORM	T	24.0		② 24.0
612067	DESICCANT CANISTER - LARGE	T	11.5		② 11.5
612068	DESICCANT CANISTER - MEDIUM	T	9.0		① 9 0
612071	ACTIVE ENVIRONMENT CONTROL CART	T	33.0		
612080	PORTABLE LEAK DETECTOR UNIT	P	2.5	2.5	
612084	FREON SERVICER	P	25.0	25.0	
612086	FREON LEAK DETECTOR	P	1.0	1.0	
612106	ROAD TIEDOWN KIT	T	10.5		10.5
612110	HORIZONTAL SLING KIT	T	53.5		53 5
612113	TRUNNION HOLDING FITTINGS	T	1.0		1.0
612114	CLEANING KIT	P	11.5	11.5	
612115	REFRIGERATION UNIT	P	101.0	101.0	
612XXX	RACK COOLING UNIT	P	50.5	50.5	
612XXX	OPERATORS CONSOLE	P	80.0	80.0	
613039	GROUNDING/BONDING TESTER	P	31.0	31.0	
614022	DESICCANT DRYING OVEN	P	27.5	27 5	
614XXX	TRANSPORTATION INSTRUMENTATION	T	20.0		20.0
	TOTALS			369.0	324 5
	O = Quantity of Items				

Table 3-45. ATL GSE Requirements (Option B-4)

END ITEM NO.	DESCRIPTION	P/T	UNIT COST ($K)	TOT. COST ($K) P	TOT. COST ($K) T
612002	TRANSPORT DOLLY	P	33.0	33.0	
612006	VERTICAL SLING KIT	T	10.5		10.5
612008	FEED-THROUGH PROTECTIVE COVERS	T	3.0		3.0
612010	PALLET SEGMENT FLOOR COVERS	P	3.5		3.5
612013	PALLET SEGMENT SUPPORT	T	47.0		47.0
612040	OPTICAL ALIGNMENT KIT	P	6.0	6 0	
612047	RACKS & FLOOR SHIPPING COVER	T	8.0		8.0
612048	RACKS & FLOOR TRANSPORT PLATFORM	T	24.0		24.0
612049	RACKS & FLOOR SUPPORT BRACES	T	2.5		2.5
612050	DOUBLE RACK HANDLING & TRANSPORT KIT	T	9.0		
612059	PALLET COVER	T	12.5		② 12.5
612060	PALLET PLATFORM	T	24.0		② 24.0
612067	DESICCANT CANISTER - LARGE	T	11.5		
612068	DESICCANT CANISTER - MEDIUM	T	9.0		
612071	ACTIVE ENVIRONMENT CONTROL CART	T	33.0		33.0
612080	PORTABLE LEAK DETECTOR UNIT	P	2.5	2.5	
612084	FREON SERVICER	P	25.0	25.0	
612086	FREON LEAK DETECTOR	P	1.0	1.0	
612106	ROAD TIEDOWN KIT	T	10.5		10.5
612110	HORIZONTAL SLING KIT	T	53.5		53.5
612113	TRUNNION HOLDING FITTINGS	T	1.0		1.0
612114	CLEANING KIT	P	11.5	11.5	
612115	REFRIGERATION UNIT	P	101.0	101.0	
612XXX	RACK COOLING UNIT	P	50.5	50.5	
612XXX	OPERATORS CONSOLE	P	80.0	80.0	
613039	GROUNDING/BONDING TESTER	P	31.0	31.0	
614022	DESICCANT DRYING OVEN	P	27.5	27.5	
614XXX	TRANSPORTATION INSTRUMENTATION	T	20.0		20.0
	TOTALS			369.0	289.5
	O = Quantity of Items				

GSE Requirements by Option

In the previous sections, we have discussed and presented the GSE requirements for a single set at each integrating location studied. In this section, the GSE requirements for all four payloads will be integrated together in proportion to their flight rate in accordance with the Baseline Traffic Model. Tables 3-46 through 3-51 presents the total costs for GSE for each processing option on a year-by-year basis. All figures are in 1977 dollars, and processing and transportation GSE subsets have been totaled in all entries. The final column adds a 20% factor for spares which would be required. Spares are not included in earlier numbers of GSE items required, and so are added here only at the monetary level.

As stated before, funds for GSE procurement are entered in the year before the year in which the equipment is needed. Tables 3-46 through 3-51 present this under each payload or minicenter column by beginning with one set at each location. When the flight rate for the year (as one goes down the column) requires a second set, an entry 2T (second set of transportation GSE) or 2P (second set of processing GSE) was made in the year when the equipment was required. The money for this additional set was entered under the previous year. A similar entry was made for third and further additional GSE sets.

Table 3-52 presents a final recap of the foregoing GSE costs by option, including the 20% spares adjustment. At the bottom of the table, all figures are escalated and summarized for inflation at the rate of 7% compounded. The factors used in this escalation computation are based on 1977 as the beginning year and are as follows:

1977 - 1.000	1982 - 1.403	1987 - 1.967
1978 - 1.070	1983 - 1.501	1988 - 2.105
1979 - 1.145	1984 - 1.606	1989 - 2.252
1980 - 1.225	1985 - 1.718	1990 - 2.410
1981 - 1.311	1986 - 1.838	1991 - 2.579

Table 3-46. Annual GSE Expenditures, Baseline Traffic Model (Option A-1) (1977 $K)

OPTION A-1

YEAR	KSC	LIFE SCIENCES								ATL			COMBINED ASTRON.			SP	TOTALS	
		1	2	3	4	5	6	7	8	1	2	3	1	2	3	1	DIRECT	+ SPARES
1979										585	187.5	592.5					1365	1638
1980		344	364	199	185	185	315	185	424							513.5	2714.5	3257.4
1981													628.5	817	571.5		2017	2420.4
1982										273		251					524	628.8
1983										2T		2T						
1984										585	59	592.5		458		233	1927.5	2313
1985										2P/ 3T	2T	2P/ 3T	236.5	2T		2T	236.5	283.8
1986													2T		179.5		179.5	215.4
1987															2T			
1988																		
1989																		
1990																		
1991																		
TOTAL		344	364	199	185	185	315	185	424	1443	246.5	1436	865	1275	751	746.5	8964	10756.8

Table 3-47. Annual GSE Expenditures Baseline Traffic Model (Option A-3) (1977 $K)

OPTION A-3

YEAR	KSC	LIFE SCIENCE								ATL			COMB. ASTRON.			SP	TOTALS	
		1	2	3	4	5	6	7	8	1	2	3	1	2	3	1	DIRECT	+ SPARES
1979	342.5									585	187.5	592.5					1707.5	2049
1980		344	364	199	185	185	315	185	424							513.5	2714.5	3257.4
1981										273		251	628.5	817	571.5		2541	3049.2
1982										2T	59	2T				233	292	350.4
1983											2T			458		2T	458	549.6
1984	342.5									585		592.5	236.5	2T	179.5		1936	2323.2
1985										2P/ 3T		2P/ 3T	2T		2T			
1986														458			458	549.6
1987														3T				
1988																		
1989																		
1990																		
1991																		
TOTAL	685	344	364	199	185	185	315	185	424	1443	246.5	1436	865	1733	751	746.5	10107.0	12129.0

Table 3-48. Annual GSE Expenditures Baseline Traffic Model
(Option B-1)
(1977 $K)

OPTION B-1

YEAR	LIFE SCIENCES	ATL	COMBINED ASTRONOMY	SPACE PROCESSING	TOTALS DIRECT	TOTALS + SPARES
1979		693.5			693.5	832.2
1980	585.0			513.5	1098.5	1318.2
1981		324.5	1042.5		1367.0	1640.4
1982		2T		233.0	233.0	279.6
1983		369.0		2T	369.0	442.8
1984	2P	324.5	650.5		975.0	1170.0
1985		3T	2T			
1986						
1987						
1988						
1989						
1990						
1991						
TOTAL	585.0	1711.5	1693.0	746.5	4736.0	5683.2

Table 3-49. Annual GSE Expenditures Baseline Traffic Model
(Option B-4)
(1977 $K)

OPTION B-4

YEAR	LIFE SCIENCE	ATL	COMBINED ASTRONOMY	SPACE PROCESSING	TOTALS DIRECT	TOTALS + SPARES
1979		658.5			658.5	790.2
1980	470.5			513.5	984.0	1180.8
1981		289.5	1009.5		1299.0	1558.8
1982		2T		233.0	233.0	279.6
1983		369.0		2T	369.0	442.8
1984		2P/289.5	650.5		940.0	1128.0
1985		3T	2T			
1986						
1987						
1988						
1989						
1990						
1991						
TOTAL	470.5	1606.5	1660.0	746.5	4483.5	5380.2

TABLE 3-50, ANNUAL GSE EXPENDITURES BASELINE TRAFFIC MODEL
(OPTION C-1) (1977 $K)
COMBINED KSC GSE SET

Year	Processing GSE	Transportation GSE	Total Direct	Total With Spares
1979	369.0	324.5	693.5	832.0
1980	76.0	135.5	211.5	254.0
1981	51.0	369.5	420.5	505.0
1982	496.0		496.0	596.0
1983				
1984	496.0	829.5	1325.5	1591.0
1985				
1986				
1987				
1988				
1989				
1990				
1991				
Total	1488.0	1659.0	3147.0	3778.0

TABLE 3-51, ANNUAL GSE EXPENDITURES BASELINE TRAFFIC MODEL
(OPTION C-4) (1977 $K)
COMBINED KSC GSE SET

Year	Processing GSE	Transportation GSE	Total Direct	Total With Spares
1979	369.0	289.5	658.5	790.0
1980	76.0	14.5	90.5	190.0
1981	50.0	401.0	451.0	541.0
1982	495.0		495.0	594.0
1983				
1984	495.0	705.0	1200.0	1440.0
1985				
1986				
1987				
1988				
1989				
1990				
1991				
Total	1485.0	1410.0	2895.0	3474.0

TABLE 3-52, GSE COST SUMMARY, BASELINE TRAFFIC MODEL

		79	80	81	82	83	84	85	86	87	88	89	90	91	Totals
1977 Dollars	A-1	1638	3257	2420	629	-	2313	284	215						10,756
	A-3	2050	3257	3049	350	550	2323		550						12,129
	B-1	832	1318	1640	280	443	1170								5,683
	B-4	790	1181	1559	280	443	1128								5,381
	C-1	832	254	505	596		1591								3,778
	C-4	790	109	541	596		1440								3,474
Escalated	A-1	1876	3990	3173	882	-	3715	488	395						14,519
	A-3	2347	3990	3997	491	825	3731	-	1011						16,392
	B-1	953	1615	2150	393	665	1879	-	-						7,655
	B-4	905	1447	2044	393	665	1812	-	-						7,266
	C-1	953	311	662	836	-	2555	-	-						5,317
	C-4	905	134	709	833	-	2313	-	-						4,894

SPACELAB FLIGHT HARDWARE

Spacelab Flight Hardware Element Evaluated

The quantities of Spacelab Flight Hardware required to support each of the four design reference missions were established by an analysis of the serial ground processing times for the element of Spacelab hardware being evaluated and by the proximity of launch dates for the payload being evaluated. Table 3-53 lists the major elements of Spacelab flight hardware that were evaluated as a part of these programmatics analyses.

Table 3-53. Spacelab Flight Hardware Items

ELEMENT	COST (1977 $M)	ELEMENT	COST (1977 $ M)
Core Module	35.0	Rack - Single	0.179
Igloo	10.0	Rack - Double	0.229
IPS	10.0	EPDB	0.088
SIPS	1.5	Floor Segment	0.039
Pallet Segment	3.022	Cold Plate	0.027
RAU	0.143		

The costs for these elements were supplied as a study input by NASA. The quantity of each of these items that are required to support a given program are determined by:

- involvement time in the ground processing flows of each option
- quantities required for a given payload configuration
- flight rate and launch schedule of the payload configuration for any given year of the traffic model.

The summary of the serial ground processing times for each configuration and ground processing options is discussed in the section entitled Traffic Model Analysis of this volume. These processing times were utilized throughout this section in the determination of the final equipment complements.

Table 3-54 illustrates the specific quantities of each of the major hardware end items required by each of the reference payloads.

Table 3-54. Payload Spacelab Flight Hardware Requirements

SPACELAB HARDWARE ELEMENT	PAYLOAD			
	S/P	C/A	L/S	ATL
Core Module	-	-	1	1
Igloo	1	1	-	-
IPS	-	1	-	-
SIPS	-	1	-	-
Pallet Segment	1	5	-	2
RAU	1	9	4	4
Rack-Single	-	-	4	2
Rack-Double	-	-	6	2
EPDB	1	5	3	3
Floor Segment	-	-	3	1
Cold Plates	4	5	-	4

Some of the Spacelab flight hardware end items evaluated related to only a portion of the four design reference payloads (e.g. Core Modules only pertain to the habitable module payloads Life Science (LS) and Advanced Technology Laboratory (ATL) and Igloos only pertain to the two pallet only payloads - Space Processing(S/P) and Combined Astronomy (C/A). There are two items, RAU's and EPSB, that are required by all payload configurations.

The flight rates of each of these four payloads is shown on Table 3-55. The derivation of this Baseline Traffic Model ftom an equivalency analysis of the "560" mission model and the studies of the four design reference missions is defined in detail in the section entitled "Traffic Model Analysis" of this volume. The launch dates of each of these missions is also defined and listed in that section.

Table 3-55. Design Reference Mission Flight Rate (Baseline Traffic Model)

PAYLOAD	YEAR											
	1980	81	82	83	84	85	86	87	88	89	90	91
Space Processing	-	3	2	7	7	8	7	8	8	9	8	8
Combined Astronomy	-	-	1	4	5	9	9	10	9	9	9	9
Life Science	-	2	2	2	2.	2	2	2	2	2	2	2
ATL	1	3	4	7	10	14	12	15	14	15	15	16
TOTALS	1	8	9	20	24	33	30	35	33	35	34	35

Derivation of Flight Hardware Quantities

As stated earlier, there are three things that determine how much flight hardware will be needed on a specific payload and/or mission. One of these three - the specific items required by the configuration - is fixed and a constant. For example, every time a Combined Astronomy payload is involved in Level IV integration activities, 5 EPDB's and 5 cold plates (see Table 3-54) are required. The influence of the ground processing flows are measured by the length of the processing activities. For example, if during a typical year (260 working days = 52 weeks/year X 5 days/week), an igloo is involved for 45 working days; then that particular piece of equipment would be able to at best support 6 processing cycles per year.

$$\frac{\text{260 available working days/year}}{\text{45 working days/cycle}} = \text{6 cycles/year} .$$

The next important variable in the determination of the quantities of Spacelab flight hardware requirements is the launch schedule and flight rate. Both factors are important because as illustrated in Figure 3-10 the flight rate without a launch schedule can be misleading.

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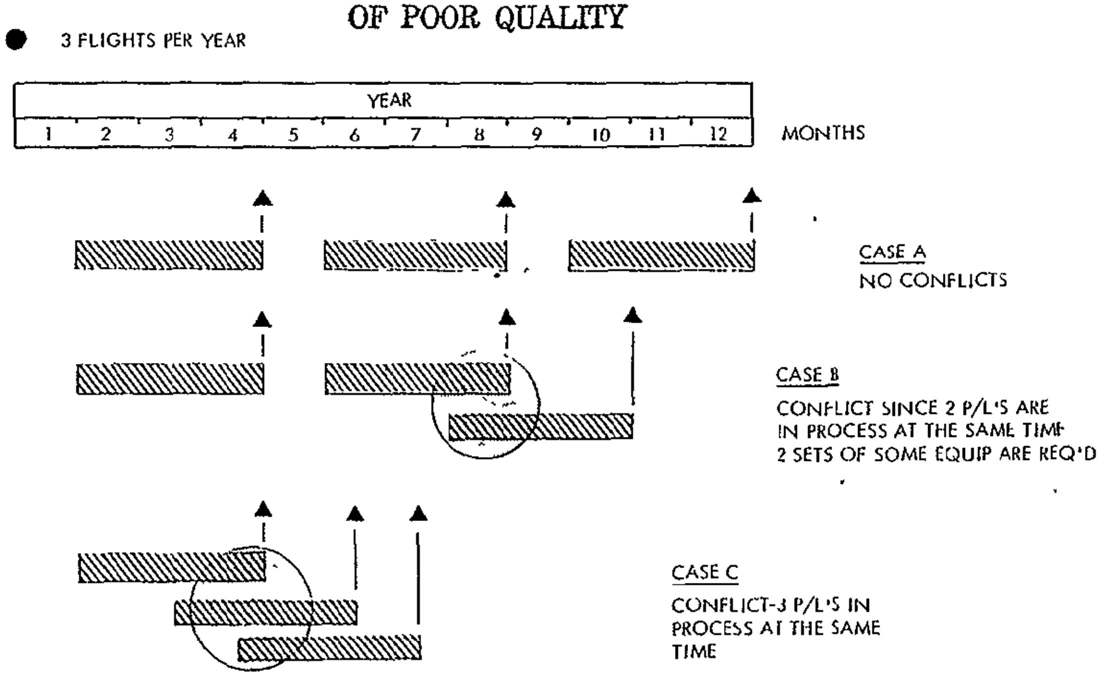

Figure 3-10. Launch Schedule Impacts

Illustrated in the figure are three cases of one flight rate - 3 flights per year. In the first case, there are no equipment conflicts because the launch dates are farther apart (4 months) than the length of the processing cycle (3 months). However, in the second example, the second and third flights are only two months apart. In order to meet this launch schedule, two sets of equipment would be required. In the third case (C), there is one and a half months between the first and second launch and one month between the second and third. In this example, possible three sets of equipment would be required to facilitate this launch schedule. Therefore, it can be easily seen from the illustration that the launch schedule can be of greater importance that the annual launch rate. With this in mind, the launch dates of each flight of the baseline traffic model were established to provide the maximum possible separation in launch dates (equi-centered) of each configuration both within a configuration and also between different types of payloads.

The determination of the individual launch dates is defined in the "Traffic Model Analysis" section of this volume. Ground processing flows were developed (see Volume II, Ground Processing Requirements) for each payload and each viable ground processing option. A summary of the serial ground processing times for each major activity block of each payload option is contained in Table 3-1 of the Traffic Model Analysis section. Figure 3-11 illustrates how these ground processing flow times influence the Spacelab flight hardware quantities.

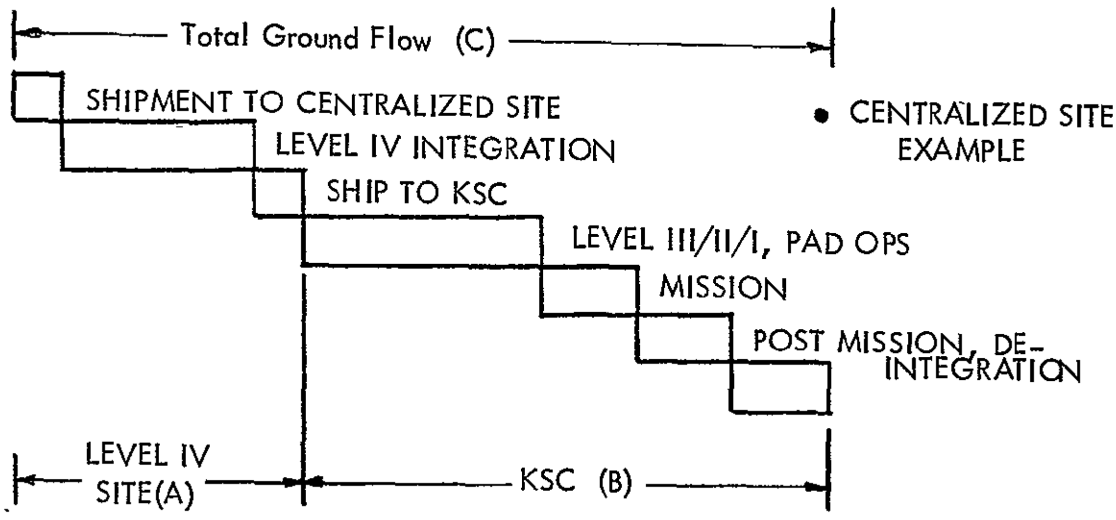

Figure 3-11. Ground Processing Flow Impact

In the example above, the Spacelab flight hardware end items are involved during either just the activities beginning with Level III or during the entire ground processing flow. In the case of the distributed (A-1 and A-3) and the centralized options (B-1 and B-4), there are varying amount of time for the shipment of equipment from the KSC staging operations to the level IV integration site. This transportation time varied from 5 serial processing days in the distributed and centralized options to 2 days in the KSC options. Based on existing NASA decisions and selections arrived at during the evaluation of the study system level trades, it has been determined that the first four items (Core Module, Igloo, IPS, and SIPS) would remain at KSC and would not be sent to level IV integration sites. The other seven hardware end items will be staged at KSC and then sent to the level IV integration for installation and subsequent checkout of the experiment equipment with their Spacelab mounting element.

The Core Module requirements for all options are shown in Table 3-56. These module requirements were derived from an analysis of the ground processing (involvement times of the Core Module in the KSC flows for the ATL payload and the Life Science payloads. The serial processing time estimates are 41.6 days for ATL and 39.2 days for Life Science type payloads(1). Learning curve factors have been applied to the first four launches of the traffic model and evaluated to determine the latest date at which additional Spacelab flight hardware would be required.

(1) NASA/ESA SPACELAB GROUND OPERATIONS ASSESSMENT AND ANALYSIS REPORT, Dated 22 July 1977 (MDC Y0001).

Table 3-56. Core Module Requirements for all Options (Baseline Traffic Model)

YEAR	FLIGHTS			TOTAL PROCESSING DAYS	UNITS REQ'D	% UTIL.
	LS	ATL	TOTAL			
1980	-	1	1	71	1	27
1981	2	3	5	231	-	88.8
1982	2	4	6	245	-	94.2
1983	2	7	9	370	2	71.1
1984	2	10	12	494	-	95.1
1985	2	14	16	661	3	84.7
1986	2	12	14	578	-	74.1
1987	2	15	17	702	-	90.1
1988	2	14	16	661	-	84.7
1989	2	15	17	702	-	90.1
1990	2	15	17	702	-	90.1
1991	2	16	18	744	-	95.4

Figure 3-12 illustrates an example of the type of analysis that was conducted to determine the need dates of additional equipment. The figure, using Option B-1 as an example, contains both the Level IV processing times indicated by the bar marked with the payload type and the number of that particular mission. It also shows the processing steps at KSC following shipment of the integrated pallets and/or racks from the centralized location. The KSC involvement times are indicated by the shaded bars. As can be seen from the learning curve plotted at the left hand side of the figure, varying learning factors were applied to the steady state values for each of the first four missions. These dates were then analyzed to determine their impact of Spacelab flight hardware, GSE, and manpower. The time difference between the launch dates of the third ATL mission and the first Life Science mission is 33 days. The Life Science involvement time forthe Core Module is 39.2 days. The shaded circle illustrates the potential conflict that would result from these dates and ground processing flow times. As defined, the 80% learning curve and the launch rate of 5 habitable module flights on the second year of the program would require two Core Modules to support the schedules. An evaluation showed that with either a seven day delay in launch date for the LS payload or an advancement of seven days in the ATL flight could postpone the requirement for the second Core Module until 1983, the fourth year of the traffic module, when there are nine habitable module flights. The third Core Module is

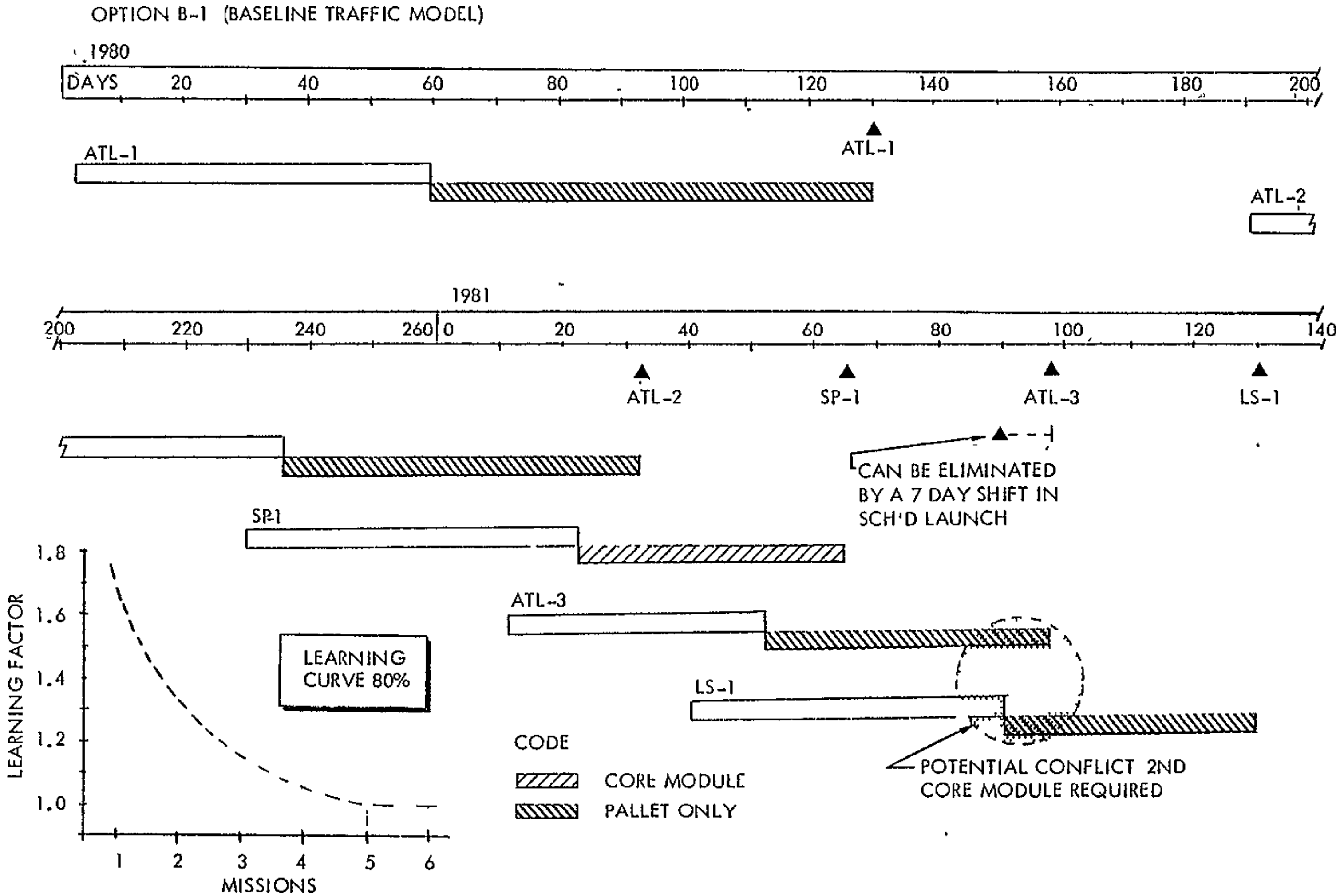

Figure 3-12. Early Mission Buildup Analysis

required in 1985 when the flight rate reaches 16 flights per year. Table 3-57 illustrates the number of flights per year a Core Module can support and the percent utilized for each hardware element.

Table 3-57. Core Module Flight Rate Capability

UNITS	FLIGHTS	PERCENT UTIL.
1	6	93.2
2	12	93.2
3	19	98.4

These figures are based on a mix of half LS and half ATL flights. They are also based on their being at least 21 days between flights when there are two in the inventory and 14 days for the case with three Core Modules.

The Igloo requirements were established using the same methodology. The processing times, learning curves, and minimum delta between launch dates were analyzed to establish the required flight hardware complements.

The Igloo requirements for all options of the baseline traffic model are illustrated in Table 3-58. As in the Core Module example, this table lists the Igloo's required to support a program with the indicated launch rate and schedule. It also contains a column marked percentage utilization (% Util.). This data quantitizes the percentage of the available working days in a given year that these Igloos are involved in the ground processing flows, from the initiation of Level III/II activities at the O&C building through the completion of the deintegration operations following a mission. The example, Table 3-59 indicates that in 1987 to support the flight rate of 18 pallet only launches that year there would be 3 Igloos required and further each one of them would be utilized an average of 78.9 percent of the available working days that year. The remaining 21.1% of the time could be available for unspecified activities such as contingencies, schedule slips or unplanned or unscheduled maintenance to the subsystems in the Igloo. Also from Table 3-58, it can be seen that these three Igloos, with proper scheduling, are capable of supporting an additional four pallet only launches.

Table 3-58. Igloo Requirements for All Options
(Baseline Traffic Model)

YEAR	FLIGHTS			TOTAL PROCESSING DAYS	UNITS REQ'D	% UTIL.
	CA	SP	TOTAL			
1980	-	-	-			-
1981	-	3	3	143	1	55.0
1982	1	2	3	105		39.6
1983	4	7	11	376	2	72.3
1984	5	7	12	410		78.9
1985	9	8	17	581	3	74.5
1986	9	7	16	547		70.2
1987	10	8	18	616		78.9
1988	9	8	17	581		74.5
1989	9	9	18	616		78.9
1990	9	8	17	581		74.5
1991	9	8	17	581		74.5

Table 3-59. Igloo Flight Rate Capability

UNITS	FLIGHTS	PERCENT UTIL.
1	7	92.0
2	15	98.7
3	22	96.5

These figures are based on a total program launch schedule that allows at least 34 days between launches in the case of one Igloo, 17 days minimum delta for 2 Igloos and 11.3 days in the three-Igloo case.

The Instrument Pointing System (IPS) and the Small Instrument Pointing System (SIPS) flight hardware requirements are contained in Table 3-60.

Table 3-60. IPS and SIPS Hardware Requirements

YEAR	FLTS C/A	TOTAL PROC DAYS	UNITS REQ'D		% UTIL	
			SIPS	IPS	SIPS	IPS
1980	-	-				
1981	-	-				
1982	1	37	2	1	14.3	7.2
1983	4	149	2		57.2	28.6
1984	5	186	2		71.5	35.8
1985	9	335	3		64.4	32.2
1986	9	335			64.4	32.2
1987	10	372			71.5	35.8
1988	9	335			64.4	32.2
1989	9	335			64.4	32.2
1990	9	335			64.4	32.2
1991	9	335			64.4	32.2

These quantities were established utilizing the study groundrule that there would be an additional SIPS added to the inventory to accommodate those planned missions that would be flown with two SIPS pedestals and 4 canisters.

The IPS quantity was determined by the groundrule that the IPS would be flown on every other Combined Astronomy payload. Therefore, under those conditions, one IPS can support the entire traffic model.

Spacelab Flight Hardware Requirements by Option

In the previous sections, the hardware requirements for Core Modules, Igloos, IPS, and SIPS were defined. These programmatic quantity requirements were determined for all six options. This was possible because these end items do not leave the KSC area and are not shipped to the Level IV integration area. The remaining seven elements of Spacelab

flight hardware are influenced by the ground processing option being evaluated and their quantities vary across the processing options.

The six options evaluated as a part of the programmatics analysis are discussed in detail in the section entitled "Traffic Model Analysis" of this volume. The selection procedure will not be repeated here. The following six sections, however, will contain the defined Spacelab flight hardware requirements for each of the six selected options (A-1, A-3, B-1, B-4, C-1, C-4).

Option A-1 Spacelab Flight Hardware Requirements

The rack and pallet requirements to support the four design reference missions and the Baseline traffic model of Option A-1 are contained in Table 3-61.

Table 3-61. Option A-1 Rack & Pallet Requirements

YEAR	ATL		LS		C/A		S/P		TOTALS	
	R	P	R	P	R	P	R	P	R	P
1980	2S 2D	2		N/A	N/A		N/A		2S 2D	2
1981	4S 4D	4	4S 4D					1	8S 8D	5
1982						5				10
1983		6						2		13
1984	6S 6D	8				10			10S 12D	20
1985	8S 8D	10				15		3	12S 14D	28
1986										
1987										
1988										
1989										
1990										
1991									12S 14D	28

R = Rack 2S - 2Single
P = Pallet 2D = 2Double
N/A = Not Applicable

The RAU, cold plate, and floor segment requirements for Option A-1 are listed in Table 3-62.

Table 3-62. Option A-1 RAU, Cold Plate and Floor Segment Requirements

YEAR	ATL			LS		SP		CA		TOTALS		
	R	CP	FLR	R	FLR	R	CP	R	CP	R	CP	FLR
1980	4	4	1							4	4	1
1981				4	2	1	4			9	8	3
1982	8	8	2					9	5	22	17	4
1983						2	8			23	21	4
1984	12	12	3					18	10	36	30	5
1985	16	16	4			3	12	27	15	50	43	6
1986										50	43	6
1987	20	20	5							54	47	7
1988										54	47	7
1989										54	47	7
1990										54	47	7
1991										54	47	7

R = RAU, CP = Cold Plate, FLR = Floor Segment

The Experiment Power Distribution Boxes (EPDB's) required to support the traffic model are driven by the payload configurations being evaluated. Table 3-63 contains the number of EPDB's required by each payload and during each year of the Option A-1 program.

Table 3-63. Option A-1 EPDB Requirements

YEAR	80	81	82	83	84	85	86	87	88	89	90	91
EPDB'S REQ'D	3	8	13	16	24	34	34	34	34	34	34	34

- EPDB Requirements per configuration: One/Pallet, one per core segment, two per experiment segment

	CS	ES	P	Total
ATL	1	-	2	3
LS	1	2	-	3
CA	-	-	5	5
SP	-	-	1	1

The rack and pallet requirements for options A-3, B-1, B-4, C-1, and C-4 are contained in Tables 3-64 through 3-68.

Table 3-64. Option A-3 Rack and Pallet Requirements

YEAR	ATL		LS		CA		SP		TOTALS	
	R	P	R	P	R	P	R	P	R	P
1980	2S 2D	2		N/A	N/A		N/A		2S 2D	2
1981	4S 4D	4	4S 6D					1	8S 10D	5
1982		6				5		1	8S 10D	12
1983	6S 6D	8				5		2	10S 12D	15
1984		10				10		2	10S 12D	22
1985	10S 10D	12				15		3	14S 16D	30
1986										
1987										
1988										
1989										
1990										
1991									14S 16D	30

Note 1 R = Rack, P = Pallet, S = Single, D = Double, N/A = Not Applicable

Table 3-65. Option B-1 Rack and Pallet Requirements

YEAR	ATL		LS		CA		SP		TOTALS	
	R	P	R	P	R	P	R	P	R	P
1980	2S 2D	2		N/A	N/A		N/A		2S 2D	2
1981	4S 4D	4	4S 6D					1	8S 10D	5
1982		4				5			8S 10D	10
1983		6						2	8S 10D	13
1984	6S 6D	8				10			10S 12D	20
1985	8S 8D	10				15		3	12S 14D	28
1986		10							12S 14D	28
1987	10S 10D	12							14S 16D	30
1988										
1989										
1990										
1991									14S 16D	30

Note 1 R = Rack, P = Pallet, S = Single, D = Double, N/A = Not Applicable

Table 3-66. Option B-4 Rack and Pallet Requirements

YEAR	ATL		LS		CA		SP		TOTALS	
	R	P	R	P	R	P	R	P	R	P
1980	2S 2D	2		N/A	N/A		N/A		2S 2D	2
1981	4S 4D	4	4S 6D					1	8S 8D	5
1982						5				10
1983		6						2		13
1984	6S 6D	8				10			10S 12D	20
1985	8S 8D	10				15		3	12S 14D	28
1986										
1987	10S 10D	12				20			14S 16D	35
1988										
1989										
1990										
1991									14S 16D	35

Note 1 R = Rack, P = Pallet, S = Single, D = Double, N/A = Not Applicable

Table 3-67. Option C-1 Rack and Pallet Requirements

YEAR	ATL		LS		CA		SP		TOTALS	
	R	P	R	P	R	P	R	P	R	P
1980	2S 2D	2		N/A	N/A		N/A		2S 2D	2
1981	4S 4D	4	4S 6D					1	8S 10D	5
1982						5				10
1983		6						2		13
1984	6S 6D	8				10			10S 12D	20
1985	8S 8D	10							12S 14D	22
1986						15				27
1987								3		28
1988										
1989										
1990										
1991									12S 14D	28

Note 1 R = Rack, P = Pallet, S = Single, D = Double, N/A = Not Applicable

Table 3-68. Option C-4 Rack and Pallet Requirements

YEAR	ATL		LS		CA		SP		TOTALS	
	R	P	R	P	R	P	R	P	R	P
1980	2S 2D	2		N/A	N/A		N/A		2S 2D	2
1981	4S 4D	4	4S 6D					1	8S 10D	5
1982						5				10
1983		6						2		13
1984	6S 6D	8				10			10S 12D	20
1985	8S 8D	10				15			12S 14D	27
1986										27
1987								3		28
1988										
1989										
1990										
1991									12S 14D	28

Note 1 R = Rack, P = Pallet, S = Single, D = Double, N/A = Not Applicable

As can be seen from the tables the options that require the least amount of racks and pallets are the KSC options C-1 and C-4 and the distributed option A-1. The RAU, Cold Plate, and Floor Segment Spacelab Flight hardware requirements for options A-3 through C-4 are contained in tables 3-69 through 3-73.

Table 3-69. Option A-3 RAU, Cold Plate, and Floor Segment Requirements

YEAR	ATL			LS		SP		CA		TOTALS		
	R	CP	FLR	R	FLR	R	CP	R	CP	R	CP	FLR
1980	4	4	1							4	4	1
1981				4	2	1	4			9	8	3
1982	8	8	2					9	5	22	17	4
1983	12	12	3			3	12	18	10	37	34	5
1984	16	16	4							41	38	6
1985	20	20	5					27	15	54	47	7
1986												
1987												
1988												
1989												
1990												
1991										54	47	7

R = RAU, CP = Cold Plate, FLR = Floor Segment

Table 3-70. Option B-1 RAU, Cold Plate, and Floor Segment Requirements

YEAR	ATL			LS		SP		CA		TOTALS		
	R	CP	FLR	R	FLR	R	CP	R	CP	R	CP	FLR
1980	4	4	1							4	4	1
1981				4	2	1	4			9	8	3
1982	8	8	2					9	5	22	13	5
1983	12	12	3			2	8			27	25	6
1984								18	10	36	30	
1985	20	20	5			3	12	27	15	54	47	7
1986												
1987												
1988												
1989												
1990												
1991										54	47	7

R = RAU, CP = Cold Plate, FLR = Floor Segment

Table 3-71. Option B-4 RAU, Cold Plate, and Floor Segment Requirements

YEAR	ATL			LS		SP		CA		TOTALS		
	R	CP	FLR	R	FLR	R	CP	R	CP	R	CP	FLR
1980	4	4	1							4	4	1
1981				4	2	1	4			9	8	3
1982	8	8	2			2	8	9	5	23	21	4
1983	12	12	3					18	10	36	30	5
1984												
1985	20	20	5			3	12	27	15	54	47	7
1986												
1987												
1988												
1989												
1990												
1991										54	47	7

R = RAU, CP = Cold Plate, FLR = Floor Segment

Table 3-72. Option C-1, RAU, Cold Plate, and Floor Segment Requirements

YEAR	ATL			LS		SP		CA		TOTALS		
	R	CP	FLR	R	FLR	R	CP	R	CP	R	CP	FLR
1980	4	4	1							4	4	1
1981				4	2	1	4			9	8	3
1982	8	8	2					9	5	22	17	4
1983						2	8			23	21	
1984	12	12	3					18	10	36	30	5
1985	16	16	4							40	34	6
1986												
1987								27	15	49	39	
1988												
1989						3	12			50	43	
1990												
1991	20	20	5							54	47	7
R = RAU, CP = Cold Plate, FLR = Floor Segment												

Table 3-73. Option C-4 RAU, Cold Plate, and Floor Segment Requirements

YEAR	ATL			LS		SP		CA		TOTALS		
	R	CP	FLR	R	FLR	R	CP	R	CP	R	CP	FLR
1980	4	4	1							4	4	1
1981				4	2	1	4			9	8	3
1982	8	8	2					9	5	22	13	4
1983						2	8			23	21	
1984	12	12	3					18	10	36	30	5
1985	16	16	4					27	15	49	39	6
1986												
1987	20	20	5							53	43	7
1988												
1989						3	12			54	47	
1990												
1991										54	47	7
R = RAU, CP = Cold Plate, FLR = Floor Segment												

Table 3-74 summarizes the EPDB requirements for options A-3, B-1, B-4, C-1, and C-4.

Table 3-74. Baseline Traffic Model EPDB Requirements

OPTION	YEAR											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
A-3	3	8	15	19	24	35	←				→	35
B-1	3	8	13	16	24	33	33	36	←		→	36
B-4	3	8	13	16	24	33	33	41	←		→	41
C-1	3	8	13	16	24	27	32	33	←		→	33
C-4	3	8	13	16	24	32	32	33	←		→	33

The number of RAU's, Cold Plates, and Floor Segments required to support each of the options were identical. The only differences between options were the years in which these equipment items were required to support the traffic model. Option C-1 does not require the last four cold plates and RAU's and the last floor segment until the last year (see Table 3-72) of the traffic model when the ATL flight rate reaches its maximum of 16 missions. Option B-4 requires the equipment the earliest. All end items are required by 1985, some six years earlier than option C-1.

Spacelab Flight Hardware Cost Summaries

The following six tables 3-75 through 3-80 summarize the Spacelab flight hardware costs, including the year incurred, for each of the six program options evaluated. Included in each table are the costs of each hardware end time (study input) and the totals in 1977 dollars and the escalated (at 10% annually) annual totals. The Spacelab flight hardware costs for all six options are nearly equal. Three of the options C-1, C-4, and A-1 have the lowest total program costs (77$) of 252 million dollars with A-3 and B-1 being the next closest at approximately 259 million dollars and option B-4 being the most expensive option at 274 million dollars.

Table 3-75. Spacelab Hardware Costs (1977 $M)
(Baseline Traffic Model)

OPTION A-3	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	1.074 1.832	9.066	.715	.078	.108	.440	13.313	17.720
1981		21.154	1.859	039	.243	.616	23.911	35 006
1982	.358 .458	9.066	2.145	039	.459	.352	12.877	20.745
1983		15.110	.572	.039	.108	.440	16.269	28.829
1984	.716 .916	30.220	1.859	.039	.243	.968	34.961	68.139
1985								
1986								
1987		15.110					15.110	39.190
1988								
1989								
1990								
1991								
TOTALS	2.506 3.664	90.66	7.722	.234	1.269	3.080	124.284	219.119

Table 3-76. Spacelab Hardware Costs (1977 $M)
(Baseline Traffic Model)

OPTION A-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	1.074 1.832	9.066	.286	.078	.108	.440	12.884	17.149
1981		15.110	1.859	.039	.243	.440	17.691	25.900
1982		9.066	.143		.108	264	9.581	15.435
1983	.358 .458	21.154	1.859	.039	.243	.704	24.815	43.972
1984	.358 .458	24.176	2.002	.039	.351	.880	28.264	55 087
1985								
1986			.572	.039	.108		0 719	1.095
1987								
1988								
1989								
1990								
1991								
TOTALS	2.148 3.206	84.616	7.293	273	1.269	2.992	101.797	168.728

Table 3-77. Spacelab Hardware Costs (1977 $M)
(Baseline Traffic Model)

OPTION B-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	1.074 1.832	9.066	.715	.078	.108	.440	13.313	17.720
1981		15.110	1.859	.039	.135	.440	17.583	25.741
1982		9.066	.715	.039	.324	.264	10.408	16.767
1983	.358 .458	21.154	1.287		.135	.704	24 096	42.698
1984	.358 .458	24.176	2.574	.078	.459	.792	28.895	56.316
1985								
1986	.358 .458	6.044				.264	7.124	16.798
1987								
1988								
1989								
1990								
1991								
TOTALS	2.506 3.664	90 66	7.722	.243	1.269	3.168	109.262	185.53

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Table 3-78. Spacelab Hardware Costs (1977 $M)
(Baseline Traffic Model)

OPTION B-4	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.79S .229D	3.022	.143	039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	1.074 1.832	9.066	.715	.078	.108	.440	13.313	17.720
1981		15.110	2.002	.039	.351	.440	17.942	26.267
1982		9.066	1.859	.039	.243	.264	11.471	18.480
1983	.358 .458	21.154				.704	22.674	40.178
1984	.358 .458	24.176	2.574	.078	.459	.792	28.895	56.316
1985								
1986	.358 .458	21.154				.704	22.674	53.465
1987								
1988								
1989								
1990								
1991								
TOTALS	2.506 3.604	105.77	7.722	.273	1.269	3.608	124.812	221.916

Table 3-79. Spacelab Hardware Costs (1977 $M)
(Baseline Traffic Model)

OPTION C-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9 490
1980	1.074 1.832	9.066	.715	.078	.108	.440	13.313	17.720
1981		15.110	1.859	.039	.243	.440	17.691	25.900
1982		9.066	.143		.108	.264	9.581	15.435
1983	.358 .458	21.154	1.859	.039	.243	.704	24.815	43.972
1984	.358 .458	6.044	.572	.039	.108	.264	7.843	15.286
1985		15.110				.440	15.550	33.339
1986		3.022	1.287		.135	.088	4.532	10.686
1987								
1988			.143		.108		0.251	0.716
1989								
1990			.572	.039	.108		0.719	2.547
1991								
TOTALS	2.148 3.206	84.616	7.722	.273	1.269	2.904	102.138	175.091

Table 3-80. Spacelab Hardware Costs (1977 $M)
(Baseline Traffic Model)

OPTION C-4	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	179S 229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	039	.108	.264	7.843	9.490
1980	1.074 1.832	9.066	.715	.078	.108	.440	13.313	17.720
1981		15.110	1.859	.039	.135	.440	17.583	25.741
1982		9.066	.143		.216	.264	9.689	15.609
1983	.358 .458	21.154	1.859	.039	.243	.704	24.815	43.972
1984	.358 .458	21.154	1.859	.039	.243	.704	24.815	48.364
1985								
1986		3.022	.572	.039	.108	.088	3.839	9.052
1987								
1988			.143		.108		.251	0.716
1989								
1990								
1991								
TOTALS	2.148 3 206	84.616	7.722	.273	1.269	2.904	102.148	170 664

TRANSPORTATION COSTS

Transportation Factors

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The costs of shipment of Spacelab flight and GSE hardware to/from Level IV integration sites other than at KSC were predicated upon the total number of end items and the width of the shipment. No costs were included for shipment of experiment equipments. It was assumed that these costs would be independent of the processing option because the site of manufacture/assembly of the experiment equipment could be at a vendor, contractor, laboratory, university, etc., and thus, shipment to the integration site would be required in all options.

Two basic load types were identified: (1) the Standard Carrier and (2) the Outsized Carrier.

The Standard Carrier, Figure 3-13 , sometimes referred to as a van, is a commercial-type vehicle such as a moving van or it may be a flatbed low-boy as shown. It is of the type used daily on the public highway system without the need for special road permits for either excess weight or excess width (viz. wider than eight feet). The Outsized Carrier, in contrast to the Standard Carrier, is one which exceeds the normally accepted road widths of the public highway system. The need for such a vehicle is to accommodate the standard dual spacelab pallet train. Typical examples of Oversized Carriers are shown in Figures 3-14 and 3-15 .

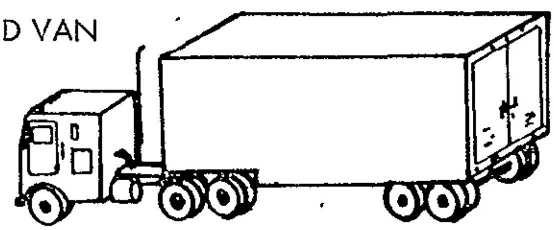
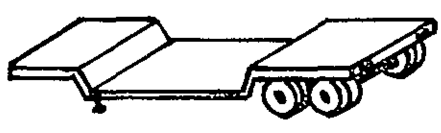
	CHARACTERISTICS	DIMENSIONS
STD VAN 	SELF-CONTAINED ECS AIR-RIDE	DOOR - 9'H X 7.6'W (INSIDE) OUTSIDE - 13' 6"H X 8'W X 45'L
FLATBED/LO-BOY 	AIR-RIDE	FLATBED OUTSIDE: 3'2"H X 8'W X 45'L LO-BOY OUTSIDE: 20"H X 8'W X 24'9"L

Figure 3-13 . Standard Carriers Characteristics

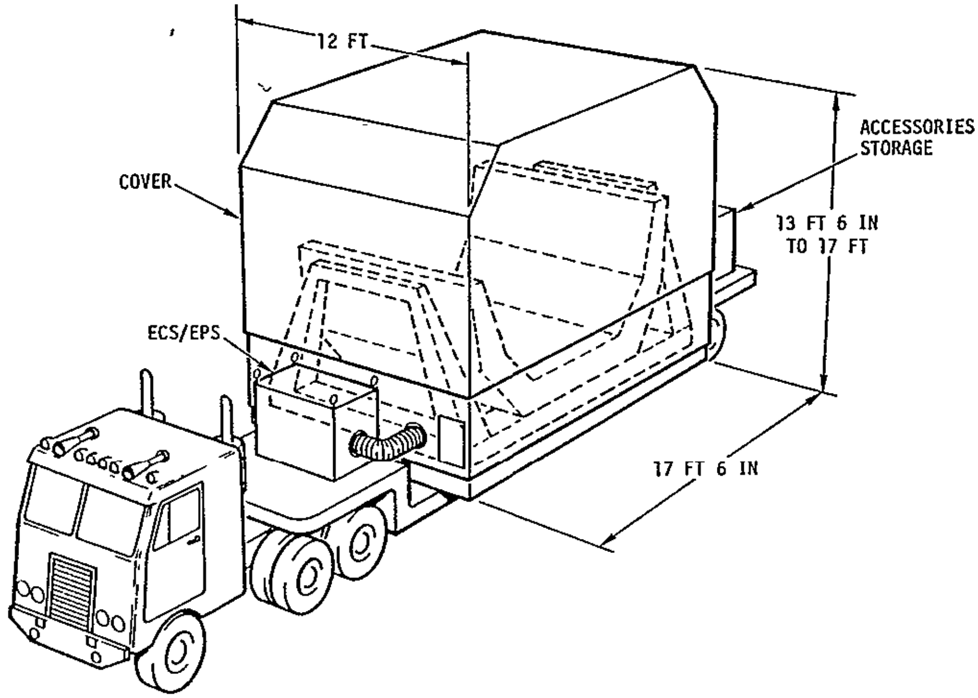


Figure 3-14 . Outsized Carrier - Single Pallet Configuration

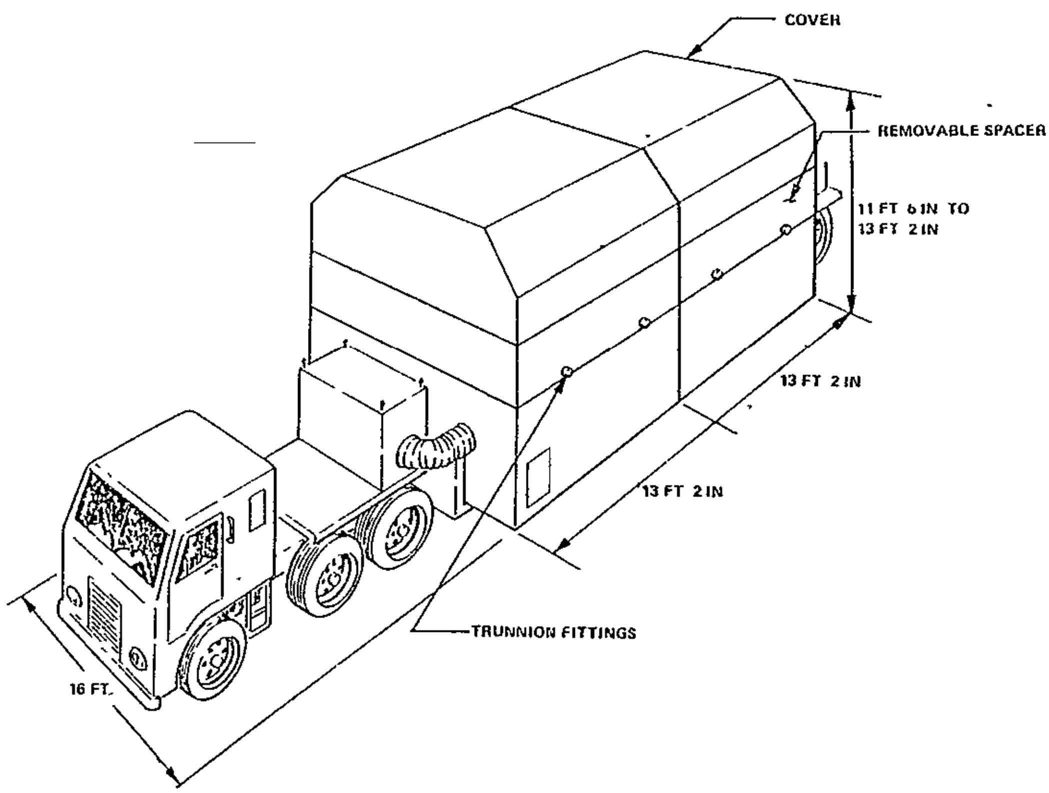


Figure 3-15 . Outsized Carrier - 2 Train Pallet Configuration

A standard single Spacelab pallet is approximately 3M (8.8 Ft.) long by 4.6M (15 Ft) wide. When placed inside a Transportation cover and mounted on a Carrier as shown in Figure 3-14 , it protrudes 2 feet on either side of the carrier exceeding the standard width by 4 feet. Similarly, with a dual pallet configuration the total width becomes 16 ft. with 4 feet overhang as shown in Figure 3-15 . In both cases, the total transportable widths exceed 8 feet and must be considered as outsized loads. The width cannot be reduced by alternate mountings of the pallets because of a height limitation of 13 feet 6 inches.

After the various types of carriers were identified, trip durations were established. For standard carriers, a single trip was maximized at two days and for outsized carriers at five days for one-way trips while using public highways. When trips were necessary between facilities at KSC, the maximum allotted time for either carrier is one day.

A similar analysis was performed to determine cost per trip. Table 3-81 is a summary of the types of vehicles used in the study and the cost per trip based on the allotted duration of a single trip. It is noted that for the condition known as DEAD HEADING (an empty return trip), no consideration was made for cost and duration.

Table 3-81 Transportation Factors

Carrier Types	Cost Per Trip ($)	Trip Duration (Days)
Outsized Carrier	4000	5
Standard Carrier (Standard Carrier - Van)	3000	2
Outsized Carrier Deadhead Return	1500	2
Standard Carrier Deadhead Return	0	0
Standard Carrier Equipment Container Shipment	3000	2
Outsized Carrier-Intra-KSC	1000	1
Standard Carrier-Intra-KSC	500	1
Standard Carrier - Partial Load	2000	2

Transportation Requirements

The costs of shipment of Spacelab flight and GSE hardware to/from Level IV integration sites other than at KSC were predicated upon the total number of end items and the width of the shipment. Shipments requiring an outsized carrier - greater than 8 feet in width - required five working days and cost $4000. Standard shipments of 8 foot in width were assumed to require two days and cost $3000.

Shipments within the KSC complex were assumed to require one day and cost $1000.

Experiment shipment costs were not included based on the assumption that they would be independent of the processing option. That is, since the experiment equipment would be manufactured or assembled at a vendor, contractor, laboratory, university, or the like, shipment to the integration site would be required in all options.

In the development of transportation costs partial shipments of equipment were avoided. If a complement of end items was estimated to require a complete truck-load, then a shipment was assumed. But piece-meal shipment of end items as a function of specific need times was not considered (see the subsequent GSE Requirements section).

Tables 3-82 thru 3-85 summarize the transportation/shipment requirements and costs for each payload and their applicable processing options. Distributed site options are the most costly because of the duplication of out-sized carrier shipments. Lead center option costs reflect the feasibility of multiple out-sized elements contained in one shipment. As expected KSC shipment costs are minimal.

Optimum Transportation Costs - Baseline Model

The following six tables, Table 3-86 through 3-91 , are summaries of the transportation costs of the six options studied in detail: A-1, A-3, B-1, B-4, C-1 and C-4. Each of the tables summarizes the studied options for each year and for the 12-year duration of the study mission model.

Table 3-82. Space Processing Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost (SK)	Total Cost (SK)
Space Processing	A-2	2 Wide Loads	4.0	8 0
		1 Standard Loads (Vans)	3.0	3.0
		2 Partial Std Loads (Vans)	2.0	4 0
				15.0
	B-2	2 Wide Loads	4.0	8.0
		1 Standard Loads (Vans)	3.0	3.0
		2 Partial Std Loads (Vans)	2.0	4.0
				15.0
	B-4	2 Wide Loads	4.0	8.0
		1 Standard Loads (Vans)	3.0	3.0
		2 Partial Std Loads (Vans)	2.0	4.0
				15.0
	C-2	2 Wide Loads (KSC)	1.0	2.0
		1 Standard Loads (Vans) (KSC)	1.0	1.0
		2 Partial Std Loads (Vans) (KSC)	5	1.0
				4.0
	C-4	2 Wide Loads (KSC)	1.0	2.0
		1 Standard Loads (Vans) (KSC)	1.0	1.0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				4.0

Table 3-83. Combined Astronomy Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost (SK)	Total Cost (SK)
Combined Astronomy	A-1	6 Wide Loads	4.0	24.0
		6 Standard Loads (Vans)	3.0	18.0
				42.0
	A-2	6 Wide Loads	4.0	24 0
		6 Standard Loads (Vans)	3.0	18.0
		2 Partial Wide Loads (KSC)	1.0	2.0
		1 Partial Std Loads (Vans) (KSC)	1.0	1.0
				45.0
	B-1	4 Wide Loads	4.0	16.0
		2 Standard Loads (Vans)	3 0	6.0
				22 0
	B-2	4 Wide Loads	4.0	16.0
		2 Standard Loads (Vans)	3.0	6.0
				22 0
	B-4	4 Wide Loads	4.0	16 0
		2 Standard Loads (Vans)	3.0	6.0
				22.0
	C-1	4 Partial Wide Loads (KSC)	.5	2.0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				3.0
	C-2	4 Partial Wide Loads (KSC)	.5	2 0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				3 0
	C-4	4 Partial Wide Loads (KSC)	.5	2.0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				3.0

Table 3-84. Life Sciences Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost ($K)	Total Cost ($K)
Life Sciences	A-1	4 Wide Loads	5.0	20.0
		16 Standard Loads (Vans)	3 0	48.0
		2 Partial Std Loads (Vans)	1.0	2.0
				70.0
	A-3	4 Wide Loads	5.0	20.0
		16 Standard Loads (Vans)	3.0	48.0
		2 Partial Std Loads (Vans)	1.0	2.0
				70.0
	B-1	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	B-3	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	B-4	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	B-5	2 Wide Loads	5.5	11 0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	C-1	1 Wide Load (KSC)	3.0	3 0
				3.0
	C-3	1 Wide Load (KSC)	3.0	3 0
				3.0
	C-4	1 Wide Load (KSC)	3.0	3.0
				3.0

Table 3-85. ATL Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost ($K)	Total Cost ($K)
ATL	A-1	4 Wide Loads	4.0	16.0
		6 Standard Loads (Vans)	3.0	18.0
				34.0
	A-3	4 Wide Loads	4 0	16.0
		6 Standard Loads (Vans)	3.0	18.0
				34.0
	B-1	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	B-3	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	B-4	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	B-5	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	C-1	2 Wide Loads (KSC)	1 0	2.0
		2 Standard Loads (Vans) (KSC)	.5	1.0
				3.0
	C-3	2 Wide Loads (KSC)	1.0	2.0
		2 Standard Loads (Vans) (KSC)	.5	1.0
				3.0
	C-4	2 Wide Loads (KSC)	1.0	2.0
		2 Standard Loads (Vans) (KSC)	.5	1.0
				3.0

Table 3-86. Summary Baseline Traffic Model Transportation Cost - Option A-1

OPTION A-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL ($K)
Combined Astronomy	-	-	42	168	210	378	378	420	378	378	378	378	3108
Space Processing	-	45	30	105	105	120	105	120	120	135	120	120	1125
Life Science	-	140	140	140	140	140	140	140	140	140	140	140	1540
Advanced Technology	34	102	136	238	340	476	408	510	476	510	510	544	4284
TOTALS ($)	34	287	348	651	795	1114	1031	1190	1114	1163	1148	1182	10057

Table 3-87. Summary Baseline Traffic Model Transportation Cost - Option A-3

OPTION A-3	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL ($)
Combined Astronomy	-	-	45	180	225	405	405	405	405	405	405	405	3285
Space Processing	-	45	30	105	105	120	105	120	120	135	120	120	1125
Life Science	-	140	140	140	140	140	140	140	140	140	140	140	1540
Advanced Technology	34	102	136	238	340	476	408	510	476	510	510	544	4284
TOTALS ($)	34	287	351	663	810	1141	1058	1175	1141	1190	1175	1209	10234

Table 3-88. Summary Baseline Traffic Model Transportation Cost - Option B-1

OPTION B-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL ($)
Combined Astronomy	-	-	22	88	110	198	198	220	198	198	198	198	1628
Space Processing	-	45	30	105	105	120	105	120	120	135	120	120	1125
Life Science	-	34	34	34	34	34	34	34	34	34	34	34	374
Advanced Technology	14	42	56	98	140	196	168	210	196	210	210	224	1764
TOTALS ($)	14	121	142	325	389	548	505	584	548	577	562	576	4891

Table 3-89. Summary Baseline Traffic Model Transportation Cost - Option B-4

OPTION B-4	YEAR											
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL ($)
Combined Astronomy	-	-	22	88	110	198	198	220	198	198	198	198	1628
Space Processing	-	45	30	105	105	120	105	120	120	135	120	120	1125
Life Science	-	34	34	34	34	34	34	34	34	34	34	34	374
Advanced Technology	14	42	56	98	140	196	168	210	196	210	210	224	1764
TOTALS ($)	14	121	142	325	389	548	505	584	548	577	562	576	4891

Table 3-90. Summary Baseline Traffic Model Transportation Cost - Option C-1

OPTION: C-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL ($)
Combined Astronomy	-	-	3	12	15	27	27	30	27	27	27	27	222
Space Processing	-	12	8	28	28	32	28	32	32	36	32	32	300
Life Science	-	6	6	6	6	6	6	6	6	6	6	6	66
Advanced Technology	3	9	12	21	30	42	36	45	42	45	45	48	378
TOTALS ($)	3	27	29	67	79	107	97	113	107	114	110	113	966

Table 3-91. Summary Baseline Traffic Model Transportation Cost - Option C-4

OPTION. C-4	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL ($)
Combined Astronomy	-	-	3	12	15	27	27	30	27	27	27	27	222
Space Processing	-	12	8	28	28	32	28	32	32	36	32	32	300
Life Science	-	6	6	6	6	6	6	6	6	6	6	6	66
Advanced Technology	3	9	12	21	30	42	36	45	42	45	45	48	378
TOTALS ($)	3	27	29	67	79	107	97	113	107	114	110	113	966

A summary table has been generated which details the various options studied with regard to the Baseline Traffic Model based on the four study payloads, Table 3-92.

OPTION. The options which were studied in detail are A-1, A-3, B-1, B-4, C-1 and C-4. There is no option A-3 for Space Processing; however, option A-2 was studied in its place.

YEAR. The mission model time span was a 12-year period scheduled from 1980 through 1991.

COST PER FLIGHT-BASELINE. These are the costs in thousands of dollars as established in the section entitled "Transportation Requirements".

NUMBER OF FLIGHTS. For each payload studied, a total number of flights are identified based on the Baseline Traffic Model for each year.

TOTAL TRANSPORTATION COSTS. The dollar amount in this column is a result of multiplying the number of flights times the transportation costs per flight (i.e., in 1984, there are 10 flights scheduled X 34(000) dollars = 340(000) dollars).

ALL PAYLOADS TOTAL. This is an accumulation of each payload's Total Transportation Cost column.

INFLATION FACTOR. An inflation factor was calculated for each of the years in the mission timeline based on an annual 7% compounded rate.

INFLATED COSTS. These are the final escalated transportation costs calculated by multiplying the straight totals by the inflation factor.

Table 3-92. Transportation Costs
(Baseline Traffic Model)

		BASELINE TRAFFIC MODEL														
PAYLOADS →		ATL			CA			LS			SP			TOTALS		
OPTION	YEAR	COST PER FLIGHT - BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COSTS PER FLIGHT - BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COSTS PER FLIGHT - BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT - BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	ALL TOTAL	INFLATION FACTOR	INFLATED COST
	1980		1	34		-	-		-	-		-	-	34	1,225	41.65
	1981		3	102		-	-		2	140		3	45	287	1,311	376 26
	1982		4	136		1	42		2			2	30	348	1,403	488,24
	1983		7	238		4	168		2			7	105	651	1.501	977.15
	1984		10	340		5	210		2			7	105	795	1,606	1276 77
	1985		14	476		9	378		2			8	120	1114	1,718	1913 85
A-1	1986	34	12	408	42	9	378	70	2		15	7	105	1031	1,838	1894,98
	1987		15	510		10	420		2			8	120	1190	1,967	2340 73
	1988		14	476		9	378		2			8	120	1114	2,105	2344.97
	1989		15	510		9	378		2			9	135	1163	2,252	2619 08
	1990		15	510		9	378		2			8	120	1148	2,410	2766,68
	1991		16	544		9	378		2	140		8	120	1182	2,579	3048 38
	1980		1	34		-	-		-	-		-	-	34	1,225	41.65
	1981		3	102		-	-		2	140		3	45	287	1,311	376.26
	1982		4	136		1	45		2			2	30	351	1,403	492.45
	1983		7	238		4	180		2			7	105	663	1.501	995.16
	1984		10	340		5	225		2			7	105	810	1 606	1300.86
	1985		14	476		9	405		2			8	120	1141	1 718	1960 24
A-3 (A2 FOR SP)	1986	34	12	408	45	9	405	70	2		15	7	105	1058	1 838	1944 60
	1987		15	510		10	450		2			8	120	1220	1 967	2399.74
	1988		14	476		9	405		2			8	120	1141	2,105	2401.81
	1989		15	510		9	405		2			9	135	1190	2,252	2679.88
	1990		15	510		9	405		2			8	120	1175	2,410	2831 75
	1991		16	544		9	405		2	140		8	120	1209	2 579	3118.01
	1980		1	14		-	-		-	-		-	-	14	1,225	17.15
	1981		3	42		-	-		2	34		3	45	121	1,311	158.63
	1982		4	56		1	22		2			2	30	142	1.403	199.23
	1983		7	98		4	88		2			7	105	325	1.501	487 83
	1984		10	140		5	110		2			7	105	389	1.606	624 73
	1985		14	196		9	198		2			8	120	548	1.718	941 46
B-1	1986	14	12	168	22	9	198	17	2		15	7	105	505	1.838	928.19
	1987		15	210		10	220		2			8	120	584	1 967	1148.73
	1988		14	196		9	198		2			8	120	548	2.105	1153 54
	1989		15	210		9	198		2			9	135	577	2,252	1299 40
	1990		15	210		9	198		2			8	120	562	2,410	1354 42
	1991		16	224		9	198		2	34		8	120	576	2.579	1485.50
	1980		1	14		-	-		-	-		-	-	14	1,225	17 15
	1981		3	42		-	-		2	34		3	45	121	1,311	158 63
	1982		4	56		1	22		2			2	30	142	1.403	199 23
	1983		7	98		4	88		2			7	105	325	1 501	487.83
	1984		10	140		5	110		2			7	105	389	.606	624 73
	1985		14	196		9	198		2			8	120	548	1.718	941 46
B-4	1986	14	12	168	22	9	198	17	2		15	7	105	505	1.838	928 19
	1987		15	210		10	220		2			8	120	584	1.967	1148 73
	1988		14	196		9	198		2			8	120	548	2,105	1153 54
	1989		15	210		9	198		2			9	135	577	7 252	1299.40
	1990		15	210		9	198		2			8	120	562	2,410	1354.42
	1991		16	224		9	198		2	34		8	120	576	2,579	1485.50
	1980		1	3		-	-		-	-		-	-	3	1 225	3.68
	1981		3	9		-	-		2	6		3	12	27	1,311	35.40
	1982		4	12		1	3		2			2	8	29	1.403	40.69
	1983		7	21		4	12		2			7	28	67	1 501	100.57
	1984		10	30		5	15		2			7	28	79	1 606	126.87
	1985		14	42		9	27		2			8	32	107	1.718	183.83
C-1	1986	3	12	36	3	9	27	3	2		4	7	28	97	1 838	178.29
	1987		15	45		10	30		2			8	32	113	1 967	222.27
	1988		14	42		9	27		2			8	32	107	2 105	225 24
	1989		15	45		9	27		2			9	36	114	2 252	256.73
	1990		15	45		9	27		2			8	32	110	2 410	265.10
	1991		16	48		9	27		2	6		8	32	113	2,579	291 43
	1980		1	3		-	-		-	-		-	-	3	1,225	3.68
	1981		3	9		-	-		2	6		3	12	27	1,311	35.40
	1982		4	12		1	3		2			2	8	29	1.403	40.69
	1983		7	21		4	12		2			7	28	67	1.501	100 57
	1984		10	30		5	15		2			7	28	79	1 606	126 87
	1985		14	42		9	27		2			8	32	107	1.718	183.83
C-4	1986	3	12	36	3	9	27	3	2		4	7	28	97	1.838	178.29
	1987		15	45		10	30		2			8	32	113	1.967	222.27
	1988		14	42		9	27		2			8	32	107	2.105	225.24
	1989		15	45		9	27		2			9	36	114	2.252	256.73
	1990		15	45		9	27		2			8	32	110	2.410	265.10
	1991		16	48		9	27		2	6		8	32	113	2.579	291.43

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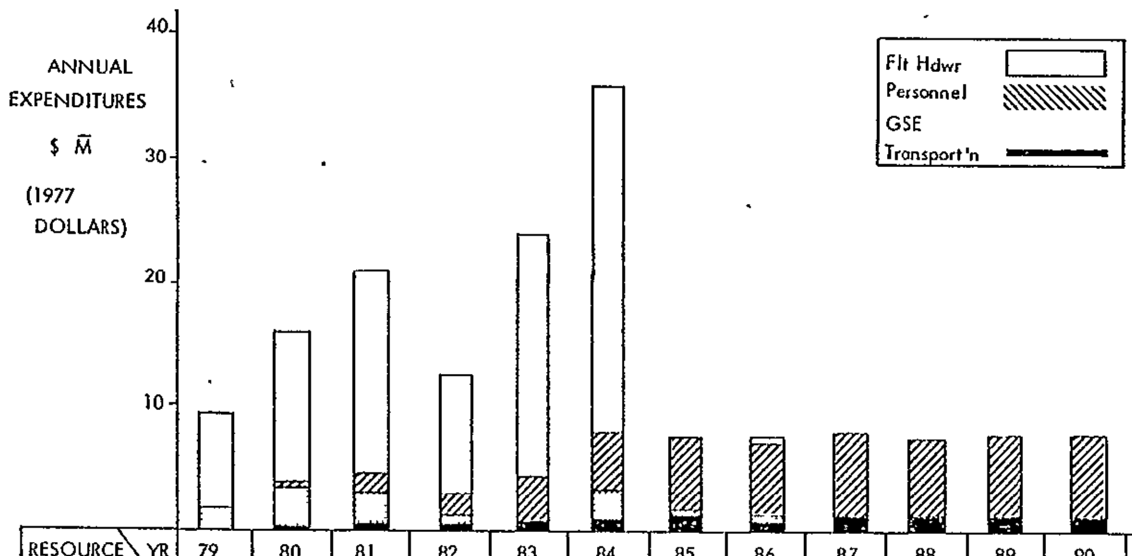
RESOURCE SUMMARY - BASELINE TRAFFIC MODEL

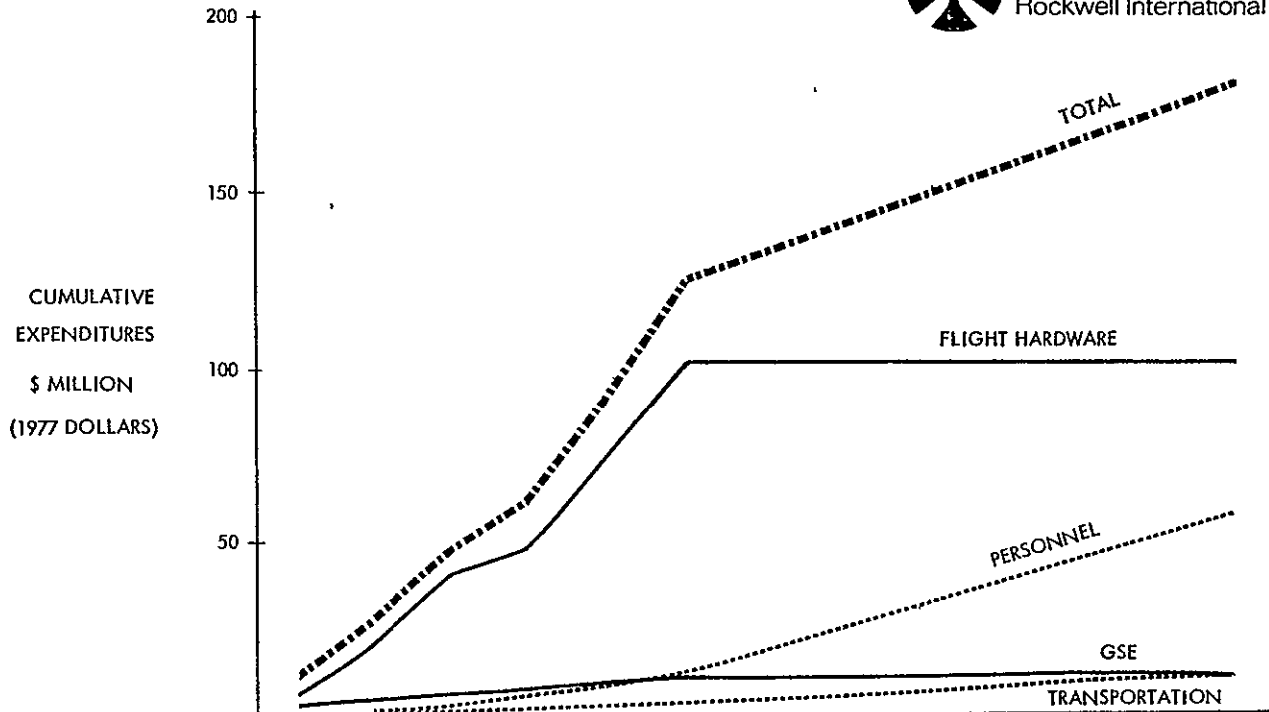
The previous six sections have defined the six options that were selected for programmatic evaluation and they have covered the traffic model analysis. Explanations are contained for the payload equivalency that defined the study extrapolation from the four design reference missions to the entire "560" mission model. The exact launch dates of each flight of the traffic model and the impact on the buildup operations of the study learning curve are also discussed in previous sections. Four major resource categories were defined: Personnel, Level IV Integration GSE, Spacelab Flight Hardware Requirements, and Transportation costs. Each of these four major resource categories is defined in detail in Sections 3.3 through 3.6 inclusively.

The summation of the costs of these resource categories and their distribution within any given year within the 12 year program are defined in this section and displayed both in tabular form and graphically. There are twelve figures (two for each option) that define the annual spending and cumulative spending requirements for all options. Figures 3-16 and 3-17 illustrate the Annual Spending and cumulative spending respectively for Option A-1 (Distributed Option - Individual Experiment C/O no pre-level III/II combined payload C/O).



RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	12.88	17.69	9.58	24.82	28 26	--	0.72	--	--	--	--	--	101.79
PERSONNEL	--	0.23	1.53	1.80	3 73	4.60	6.38	5.79	6 80	6 38	6.75	6.61	6 83	57 43
GSE	1.64	3 26	2.42	0.63	--	2.31	0 28	0.22	--	--	--	--	--	10 76
TRANSPORT'N.	--	0.03	0 29	0 35	0.65	0.80	1.11	1.03	1.19	1.11	1.16	1.15	1.18	10.05
TOTALS '77 $	9.48	16.40	21.93	12.36	29.20	35.97	7.77	7 76	7.99	7.49	7.91	7.76	8.01	180.03
ESCALATED $	11.37	21.46	31.46	19.33	50.55	67.78	13.37	14.64	15.71	15.78	17.82	18.70	20.67	318.64

Figure 3-16 . Option A-1 Resource Summary (Annual Spending)
(Baseline Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	20.72	38.41	47.99	72 81	101.07	101.07	101 79	101.79	101.79	101.79	101.79	101 79
PERSONNEL	--	0.23	1 76	3.56	7.29	11 89	18.27	24.06	30.86	37.24	43.99	50.60	57.43
GSE	1.64	4.90	7.32	7.95	7.95	10.26	10.54	10.76	10.76	10.76	10.76	10.76	10.76
TRANSPORT'N.	--	0 03	0.32	0.67	1.32	2.12	3.23	4.26	5.45	6.56	7.72	8.87	10.05
TOTALS '77 $	9.48	25 88	47.81	60.17	89.37	125 34	133.11	140.87	148.86	156 35	164.26	172.02	180.03
ESCALATED $	11.36	33.90	68.55	94.40	153 88	235.97	271 73	311.85	356.63	405.26	460.10	520.63	588.28

Figure 3-17 . Option A-1 Resource Summary (Cumulative Spending)
(Baseline Traffic Model

Below the bars in Figure 3-16 which define the total spending within any given year there are tabulations of the component elements of each bar. For example, in 1984 Figure 3-16 indicates that 35.97\overline{M}$ would be required by the program. Of that total, 28.26\overline{M}$ would be for Flight Hardware requirements; $4.6 $\overline{M}$ for Level IV hands-on personnel; $2.31 $\overline{M}$ for GSE; and $0.8 $\overline{M}$ for transportation. The figures below the annual totals are the escalated annual funding requirements. The escalation factor used was 10% for Spacelab Flight hardware and 7% of the other resource categories.

Figure 3-17 shows the cumulative spending for Option A-1. It also lists the totals both in constant dollars (1977 $) and also the escalated dollar amounts.

The majority of the resource requirements for the option are for the spacelab flight hardware end items ($101.79 -57% of the ground processing resource total). The majority of the spacelab flight hardware is required in the first five years of the program when the flight rate grows from one mission in 1980 to eight in 1981; then 20 in 1983 and 33 in 1985. The rapid growth of the flight rate requires that 70% of the flight hardware be purchased by 1983 and that 98% of it be acquired by 1984. The personnel cost requirements grow at almost the same rate as the spacelab flight hardware, but are delayed by approximately one year in reaching their peak requirements. The spacelab flight hardware costs are placed in the year preceding their first use. The manpower costs for the PI's,

their technicians and the appropriate Host Center support, KSC operations support or the TDY costs are factored into the program totals in the year in which the flight occurs. GSE costs are allocated in the same manner as the flight hardware - costs are allocated in the year preceding first use. Transportation costs are accumulated in the year that the shipment occurs.

The next ten Figures 3-18 through 3-27 illustrate both the annual funding requirements and the cumulative spending curves for the other five options evaluated.

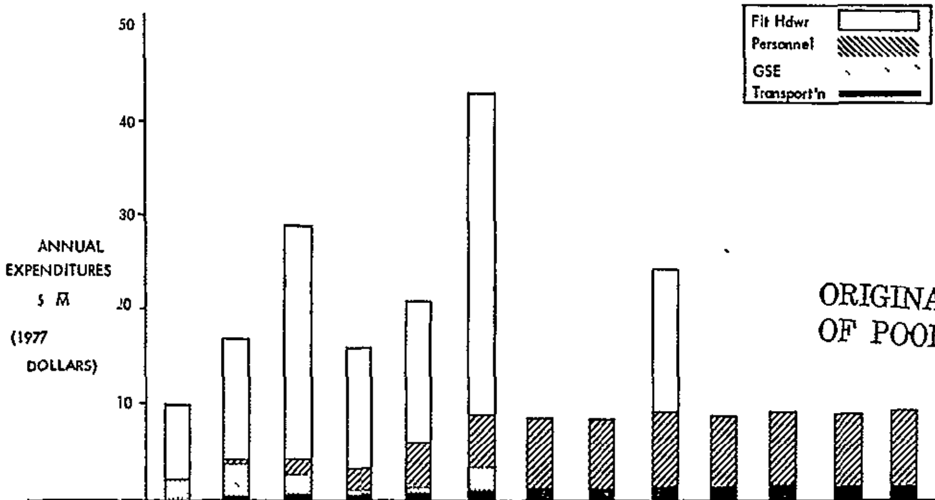
Table 3-93. Total Level IV Ground Processing Resource Summary

PROGRAM RESOURCE	OPTION					
	A-1	A-3	B-1	B-4	C-1	C-4
FLT HARDWARE	101.79	124.28	109.26	124.80	102.13	102.15
PERSONNEL	57.43	67.23	60.67	62.88	69.12	71.67
GSE	10.76	12.13	5.68	5.38	3.78	3.47
TRANSPORTATION	10.05	10.28	4.90	4.90	0.97	0.97
TOTALS	180.03	213.92	180.51	197.96	176.00	178.26

Table 3-93 contains the total Level IV ground processing resource summary for all options evaluated as a part of the analysis of the Baseline Traffic Model. The three lowest total cost options are C-1, C-4, and A-1 in that order.

The Spacelab flight hardware costs are almost identical. The KSC options C-1 and C-4 have slightly higher flight hardware costs because while the transportation times are shorter, the overall ground processing flows are almost identical and the hardware involvement times for some end items are longer because while in the distributed site approach (A-1) the checkout GSE is duplicated at each site; in the KSC (C-1 and C-4) and the centralized approach the checkout of the individual experiments is staggered to permit use of only one set of checkout GSE. In options A-1, B-1, and C-1 the checkout is not accomplished in a payload flight configuration. In options B-4 and C-4 the experiment equipment is installed in rack sets and on pallets; and all equipment, including cabling and coolant lines, are installed for all experiments prior to interface testing. The

assembled configuration is essentially the payload flight configuration. Because of the potential of sharing sets of GSE at the centralized and KSC sites the GSE costs are 50 to 60 percent lower than for the distributed options. The transportation costs for the centralized options are approximately one half of what they are for the distributed sites. While there are only four centralized sites as opposed to 15 distributed sites, the transportation cost savings are modified by the larger more expensive trips that are required in the centralized options. The personnel costs for the KSC options are higher than for their centralized or distributed counterparts because of the additional costs for TDY and Host Center support that are not as prevalent in the distributed options. The $\$16\overline{M}$ of savings in GSE and transportation costs of the C-1 option over the distributed option A-1 are almost balanced by the $\$11.7\overline{M}$ additional personnel costs for C-1. If the annual flight rate of the traffic model were to warrant the establishment of a group of KSC support personnel, then a major portion of the TDY costs in the KSC options could be saved.



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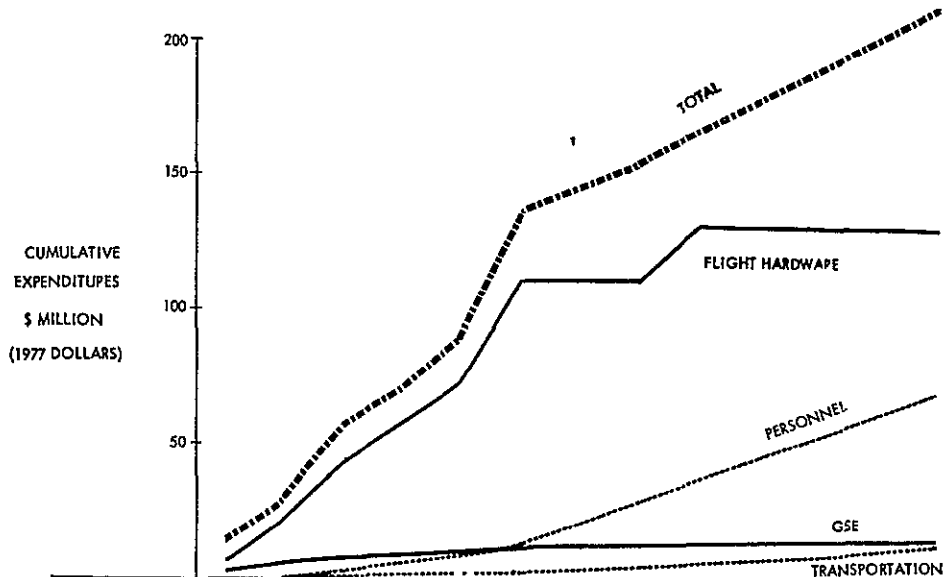
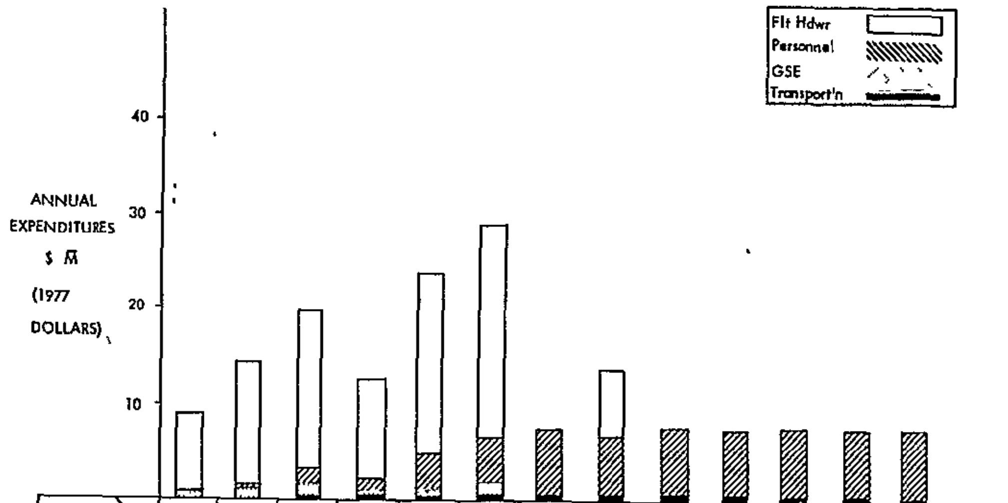
RESOURCE YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	13.31	23.91	12.88	16 27	34.96	--	--	15.11	--	--	--	--	124.28
PERSONNEL	--	0.27	1 71	2 07	4.31	5.34	7 50	6 83	8.00	7.50	7.91	7.76	8.03	67.23
GSE	2.05	3.26	3.05	0 35	0 55	2 32	--	0.55	--	--	--	--	--	12 13
TRANSPORT'N.	--	0.03	0.29	0.35	0.66	0.81	1.14	1.06	1.22	1.14	1.19	1.18	1.21	10.28
TOTALS '77 $	9 89	16 87	28.96	15.65	21.79	43.43	8.64	8.44	24.33	8.64	9.10	8.94	9.24	213.92
ESCALATED $	11.84	17 72	41.62	24.64	37.11	81.74	14.84	15.49	57.26	18.18	20.48	21.54	23.93	386.39

Figure 3-18. Option A-3 Resource Summary (Annual Spending)
(Baseline Traffic Model)



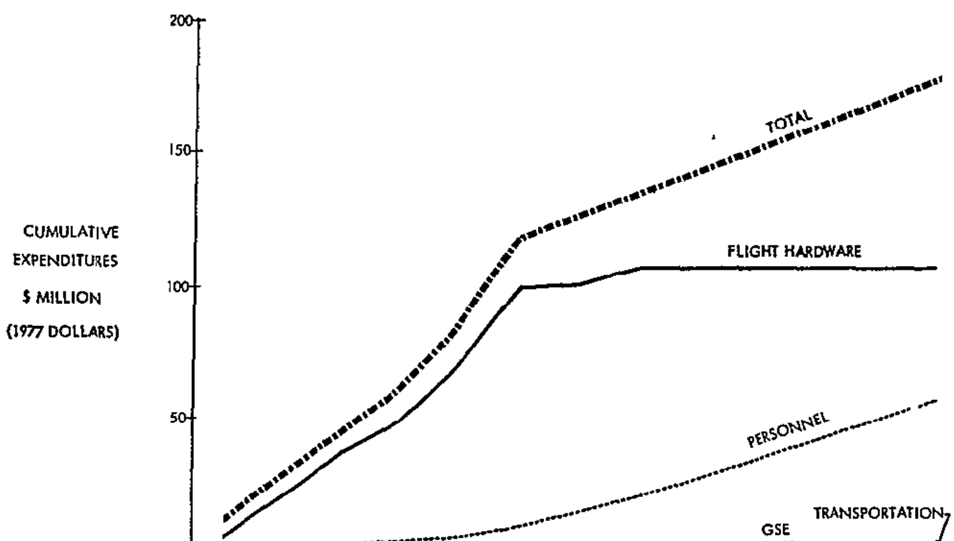
RESOURCE YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	21.15	45 06	57.94	74.21	109.17	109 17	109 17	124.28	124.28	124.28	124.28	124 28
PERSONNEL	--	0.27	1.98	4 05	8.36	13.70	21.20	28.03	36 03	43 53	51.44	59.20	67 23
GSE	2 05	5.31	8.36	8 71	9.26	11.58	11.58	12.13	12.13	12 13	12.13	12.13	12.13
TRANSPORT'N.	--	0 03	0.32	0.67	1.33	2 14	3.28	4.34	5.56	6.70	7 89	9.07	10 28
TOTALS '77 $	9 89	26.76	55.72	71.37	93.16	136.59	145.23	153.67	178.00	186.64	195.74	204.68	213.92

Figure 3-19. Option A-3 Resource Summary (Cumulative Spending)
(Baseline Traffic Model)



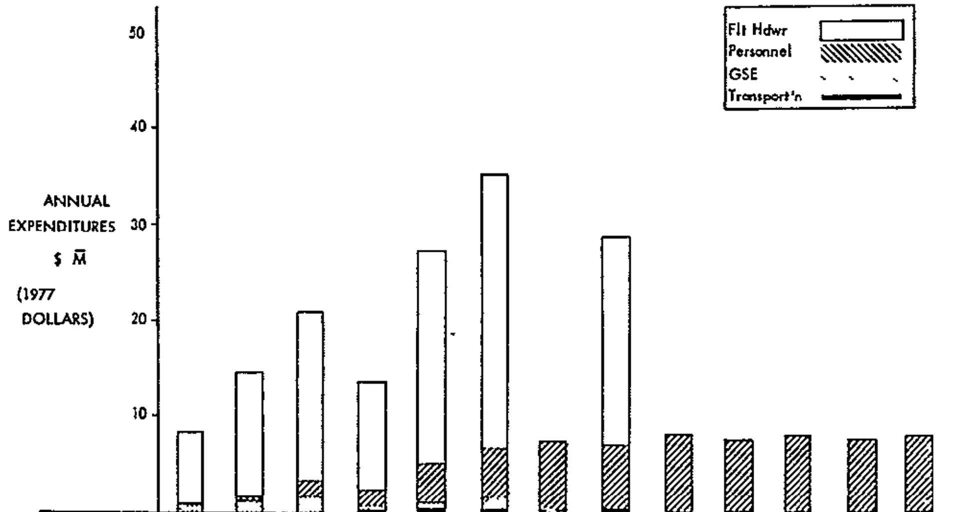
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	13.31	17 58	10.41	24 10	28.90	--	7.12	--	--	--	--	--	109.26
PERSONNEL	--	0.24	1.57	1.85	3 93	4 85	6.76	6 13	7.20	6.76	7.15	7.00	7 23	60 67
GSE	0.83	1 32	1.64	0.28	0 44	1 17	--	--	--	--	--	--	--	5 68
TRANSPORT'N.	--	0.01	0.12	0.14	0.33	0 39	0.55	0 51	0.58	0.55	0.58	0 56	0 58	4 90
TOTALS '77 $	8,67	14.88	20.91	12.68	28 80	35.31	7 31	13 76	7.78	7.31	7.73	7 56	7 81	180.51
ESCALATED $	10.44	19.64	30.11	19.95	49.76	66 62	12.55	28 99	15 30	15.37	17.40	18 21	20 15	324.49

Figure 3-20 . Option B-1 Resource Summary (Annual Spending) (Baseline Traffic Model)



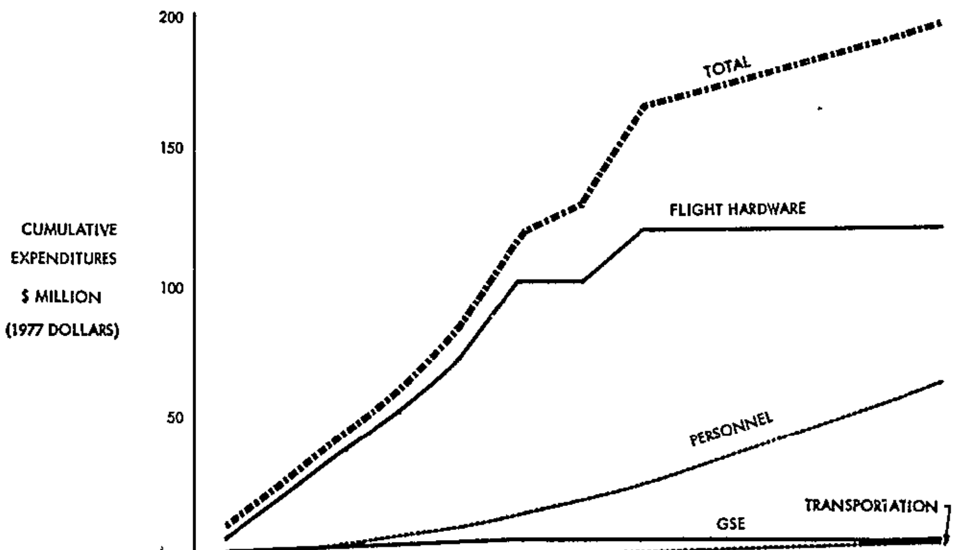
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	21.15	38.73	49 14	73.24	102.14	102.14	109 26	109.26	109.26	109 26	109.26	109.26
PERSONNEL	-	0.24	1.81	3.66	7 59	12.44	19 20	25.33	32.53	39.29	46 44	53.44	60 67
GSE	0.83	2 15	3 79	4.07	4 51	5.68	5 68	5.68	5 68	5.68	5.68	5.68	5.68
TRANSPORT'N.	-	0 01	0.13	0 27	0.60	0 99	1 54	2.05	2 63	3.18	3.76	4 32	4.90
TOTALS '77 $	8.67	23.55	44.46	57 14	85.94	121.25	128 56	142 32	150.10	157 41	165.14	172.70	180 51

Figure 3-21 . Option B-1 Resource Summary (Cumulative Spending) (Baseline Traffic Model)



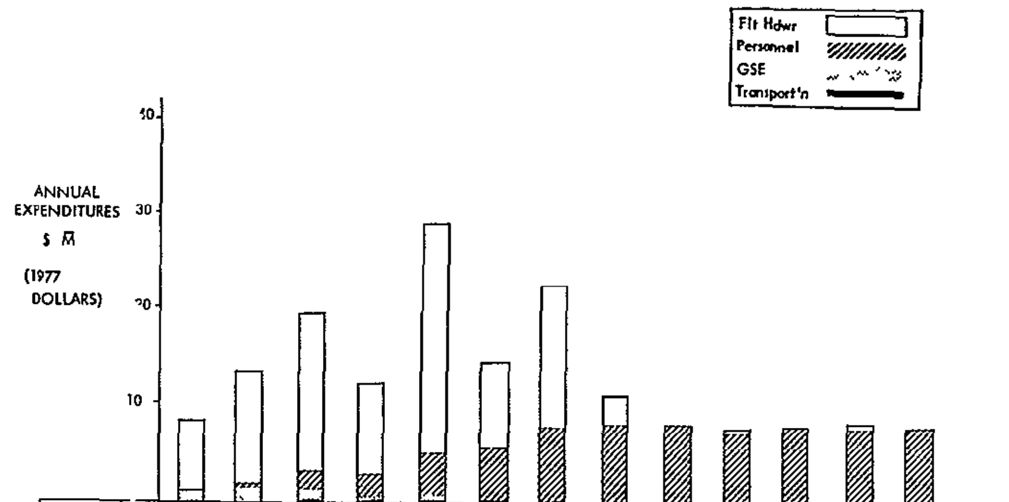
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	13.31	17 94	11.47	22 67	28.90	--	22 67	--	--	--	--	-	124 80
PERSONNEL	--	0.25	1 61	1.91	4 06	5 02	7 01	6 35	7.47	7 01	7.42	7 26	7 51	62.88
GSE	0 79	1.18	1 56	0 28	0 44	1.13	--	--	--	--	--	--	--	5.38
TRANSPORT'N	--	0 01	0 12	0 14	0 33	0.39	0.55	0 51	0 58	0.55	0 58	0.56	0 58	4 90
TOTALS '77 $	8.63	14.75	21 23	13.80	27 50	35 44	7.56	29.53	8 05	7.56	8 00	7 82	8 09	197.96
ESCALATED $	10 39	19.48	30.57	21.75	47 44	66 81	12.98	66.08	15 84	15.91	18 01	18 85	20 87	364.98

Figure 3-22. Option B-4 Resource Summary (Annual Spending) (Baseline Traffic Model)



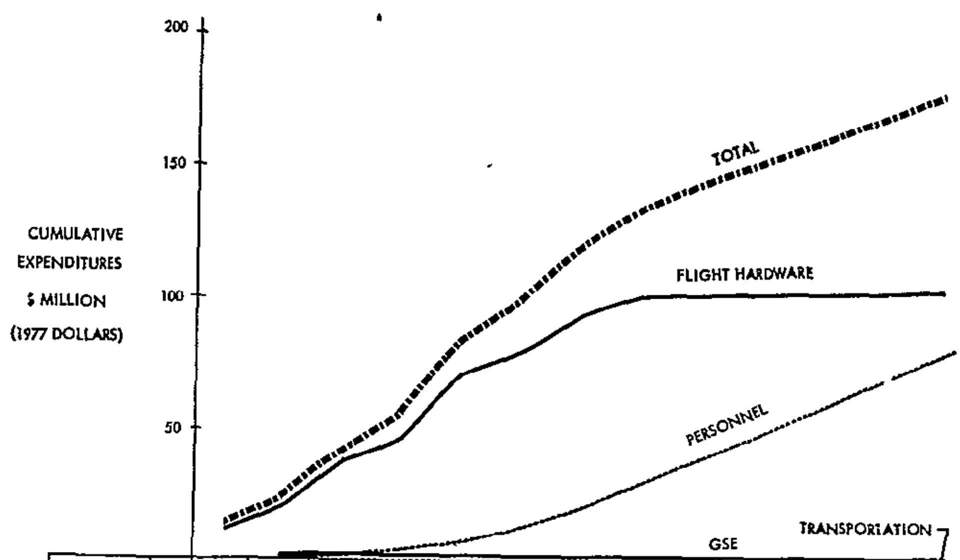
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	21.15	39.09	50 56	73.23	102.13	124.80	124.80	124.80	124.80	124 80	124 80	124 80
PERSONNEL	—	0.25	1.86	3.77	7.83	12.85	19 86	26 21	33.68	40 69	48.11	55 37	62 88
GSE	0.79	1.97	3.53	3.81	4 25	5.38	5.38	5.38	5.38	5.38	5.38	5 38	5 38
TRANSPORT'N.	--	0 01	0 13	0 27	0 60	0 99	1.54	2.05	2.63	3 18	3 76	4 32	4 90
TOTALS '77 $	8.63	23.38	44.61	58.41	85.91	121.35	128.91	158.44	166.49	174 05	182 05	189 87	197 96

Figure 3-23. Option B-4 Resource Summary (Cumulative Spending) (Baseline Traffic Model)



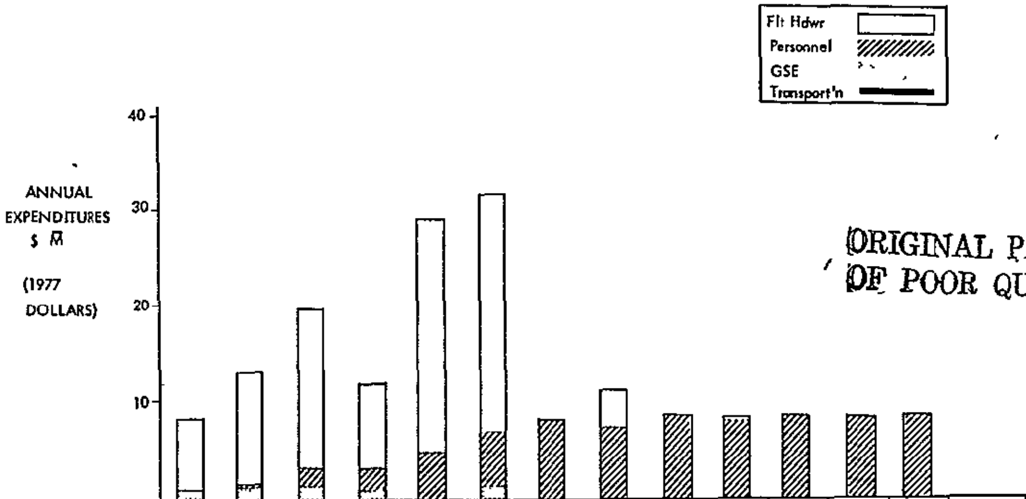
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	13.31	17 69	9.58	24 82	7.84	15 55	4.53	--	0 25	--	0.72	--	102.13
PERSONNEL	--	0 26	1 76	2.09	4 48	5.51	7 71	7.01	8 22	7.71	8.15	7 98	8 24	69 12
GSE	0 83	0.25	0 51	0 60	--	1.59	--	--	--	--	--	--	--	3 78
TRANSPORT N	--	--	0 03	0.03	0.07	0.08	0.11	0.10	0.11	0.11	0.11	0.11	0.11	0.97
TOTALS 77 $	8.67	13.82	19.99	12 30	29.37	15 02	23.37	11.64	8.33	8.07	8.26	8.81	8 35	176.00
ESCALATED $	10.44	18.34	28.92	19.25	44`08	26.81	46.77	25.80	16 38	17.18	18.61	30.35	21.54	324.47

Figure 3-24. Option C-1 Resource Summary (Annual Spending) (Baseline Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7 84	21.15	38.84	48.42	73 24	81 08	96.63	101.16	101.16	101.41	101.41	102 13	102.13
PERSONNEL	--	0 26	2.02	4.11	8.59	14.10	21.81	28.82	37 04	44 75	52 90	60 88	69.12
GSE	0.83	1 08	1:59	2 19	2.19	3.78	3.78	3.78	3 78	3.78	3.78	3 78	3.78
TRANSPORT'N.	--	--	0 03	0 06	0 13	0 21	0 32	0 42	0 53	0.64	0 75	0 86	0.97
TOTALS '77 $	8.67	22.49	42 48	54.78	84.15	99.17	122.54	134.18	142 51	150 58	158.84	167 65	176.00

Figure 3-25. Option C-1 Resource Summary (Cumulative Spending) (Baseline Traffic Model)



RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7,84	13,31	17,58	9,69	24 82	24 82	--	3,84	--	0.25	--	--	--	102,15
PERSONNEL	--	0 29	1 84	2,18	4.63	5 72	7,99	7 24	8 51	7,99	8 45	8 27	8 56	71 67
GSE	0 79	0,11	.54	.59	--	1.44	--	--	--	--	--	--	--	3 47
TRANSPO°T'N.	--	--	0 03	0, 03	0 07	0,08	0 11	0,10	0,11	0,11	0,11	0,11	0,11	0,97
TOTALS '77 $	8,63	13,71	19,99	12,49	29 52	32,06	8,10	11.18	8,62	8,35	8,56	8 38	8 67	178,26
ESCALATED $	10 39	18,21	28,90	19,54	51,02	60,00	13,90	22,53	16,95	17,76	19,29	20,20	22,36	321,05

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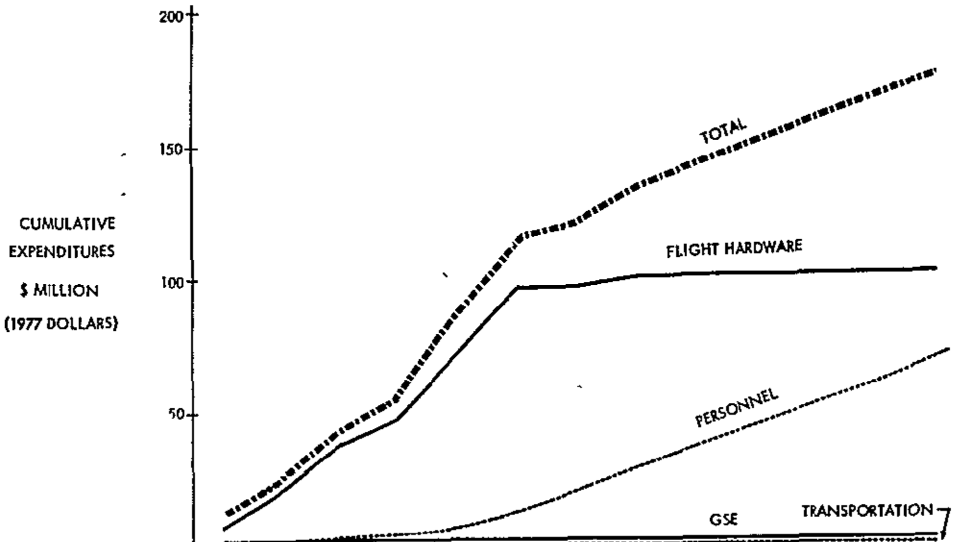
Figure 3-26. Option C-4 Resource Summary (Annual Spending) (Baseline Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7,84	21,15	38,73	48,42	73,24	98,06	98 06	101,90	101,90	102 15	102,15	102,15	102 15
PERSONNEL	--	0 29	2 13	4 31	8 94	14 66	22,65	29 89	38,40	46 39	54,84	63,11	71 67
GSE	0,79	0,90	1,44	2,03	2 03	3,47	3,47	3,47	3,47	3 47	3 47	3,47	3,47
TRANSPORT'N.	--	--	0 03	0 06	0,13	0,21	0,32	0 42	0,53	0,64	0,75	0,86	0,97
TOTALS '77 $	8,63	22,34	42 33	54 82	84,34	116 40	124 50	135,68	144,30	152,65	161,21	169,59	178,26

Figure 3-27. Option C-4 Resource Summary (Cumulative Spending) (Baseline Traffic Model)

4.0 LEVEL IV GROUND PROCESSING REQUIREMENTS - 2/3 TRAFFIC MODEL

4.0 LEVEL IV GROUND PROCESSING REQUIREMENTS - 2/3 TRAFFIC MODEL

SCOPE OF PROGRAMMATIC ANALYSIS

This section describes the programmatic analyses performed during the study based on the 2/3 Traffic Model. The same site options were considered for analysis as described in section 3.0 of this volume. The same basic guidelines itemized in an earlier section were also applied here.

The 2/3 Traffic Model is a derivation of the "560" traffic model based on the study (equivalency) model using the four selected payloads. Buildup analyses based on ground processing times were performed and included along with a schedule analyses reflecting the development of payload launch dates.

Spectrum of Options

A detailed description of the options applicable to the analysis based on a 2/3 traffic model is found in section 3.0 of this volume. The options considered for the 2/3 model were: (1) Distributed Site; (2) Lead Center; and (3) KSC. The same six buildup options were also used in the Programmatic Evaluation using similar criteria found in Section 3, "Options Selected for Programmatic Evaluation." Table 3-3 lists these options.

Programmatic Guidelines

The concept behind the "Programmatic Guidelines" found in Section 3 of this volume is applicable; however, these guidelines were adjusted as required by the reduction in the payload quantity to two-thirds of the baseline traffic model.

TRAFFIC MODEL ANALYSIS

Payload Equivalencies

Payload equivalencies were based on the "STS Traffic Manifest, 1980-1991" as described in Section 3 of this volume biased by a reduction in missions of a factor approximating 2/3.

Prior to applying the 2/3 factor an equivalency traffic model was produced relating the four study payloads to the basic model. The equivalency model is shown in Table 3-5. Table 4-1 identifies the 2/3 Traffic Model used.

Table 4-1. 2/3 Traffic Model for Programmatic Analyses

2/3	LS	-	1	1	1	1	1	1	1	1	1	1	1	11
	ATL	1	3	3	5	7	10	10	10	10	10	10	10	89
	CA	-	-	1	3	3	6	6	6	6	6	6	6	49
	SP	-	2	1	5	5	5	5	5	5	5	6	6	50
	Total	1	6	6	14	16	22	22	22	22	22	23	23	199

Buildup Analysis

The Spacelab Ground Processing times developed for the baseline traffic model were applied to the 2/3 traffic model. Similarly to the baseline buildup analysis, the NASA provided 80 percent learning curve would be applicable.

Schedule Analysis

A schedule analysis similar to that performed on the baseline traffic model was performed to derive the 2/3 mission model, the only difference being that the quantity of flights was reduced. The same ground rules and guidelines were used in the 2/3 schedule analysis as were used in the baseline model. A detailed description is found in Section 3 entitled, "Schedule Analysis." Table 4-2 is a detailed scheduling of the 2/3 mission model.

Table 4-2. 2/3 Traffic Model

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1980	1	130		X		
			-	1	-	-
1981	1	44		X		
	2	87		X		
	3	130				X
	4	174	X			
	5	217		X		
	6	260				X
			1	3	-	2
1982	1	44		X		
	2	87		X		
	3	130			X	
	4	174	X			
	5	217		X		
	6	260				X
			1	3	1	1
1983	1	19				X
	2	38		X		
	3	56			X	
	4	75		X		
	5	93				X
	6	112		X		
	7	130				X
	8	149			X	
	9	168	X			
	10	186				X
	11	205		X		
	12	223			X	
	13	242		X		
	14	260				X
			1	5	3	5

Table 4-2. 2/3 Traffic Model (Continued)

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1984	1	17		X		
	2	33				X
	3	49		X		
	4	65			X	
	5	82		X		
	6	98				X
	7	114		X		
	8	130			X	
	9	147	X			
	10	163				X
	11	179		X		
	12	195				X
	13	212		X		
	14	228			X	
	15	244		X		
	16	260				X
			1	7	3	5
1985	1	11		X		
1986	2	23			X	
1987	3	35		X		
1988	4	47				X
1989	5	59		X		
	6	71			X	
	7	82		X		
	8	94				X
	9	106		X		
	10	118			X	
	11	130	X			
	12	141				X
	13	153		X		
	14	165			X	
	15	177		X		
	16	189				X
	17	201		X		
	18	212			X	
	19	224		X		
	20	236				X
	21	248		X		
	22	260			X	
			1	10	6	5

Table 4-2. 2/3 Traffic Model (Continued)

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1990	1	11				X
1991	2	22		X		
	3	34			X	
	4	45		X		
	5	56				X
	6	68		X		
	7	79			X	
	8	90		X		
	9	102				X
	10	113		X		
	11	124			X	
	12	136	X			
	13	147				X
	14	158		X		
	15	170			X	
	16	181		X		
	17	192				X
	18	204		X		
	19	215			X	
	20	226		X		
	21	238				X
	22	249		X		
	23	260			X	
			1	10	6	6

PERSONNEL REQUIREMENTS - 2/3 TRAFFIC MODEL

The manpower and TDY requirements developed for each payload on a permission basis were described in section 3 under Personnel Requirements. These data are applicable in this section as well, including Tables 3-13 through 3-18 .

In applying the 2/3 Traffic Model to this data, the same approach was followed as with the Baseline Traffic Model. The total costs per flight for each payload were multiplied by the number of flights for that payload in the given year, to give the total cost for the year for each payload. These were then totaled for the four payloads to yield the annual grand total costs for personnel, both manpower and TDY. Payload totals are also shown for reference. This data is presented in Tables 4- 3 through 4- 8 for options A-1, A-3, B-1, B-4, C-1, and C-4 respectively.

Table 4-3. 2/3 Traffic Model
(1977 K $ - Manpower Costs)

OPTION A-1

	ATL			LIFE SCIENCE			COMB. ASTRON.			SP PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	194	31	-	-	-	-	-	-	-	-	-	194	31
1981	3	582	93	1	193	22	-	-	-	2	238	42	1,013	157
1982	3	582	93	1	193	22	1	167	20	1	119	21	1,061	156
1983	5	970	155	1	193	22	3	501	60	5	595	105	2,259	342
1984	7	1,358	217	1	193	22	3	501	60	5	595	105	2,647	404
1985	10	1,940	310	1	193	22	6	1,002	120	5	595	105	3,730	557
1986	10	1,940	310	1	193	22	6	1,002	120	5	595	105	3,730	557
1987	10	1,940	310	1	193	22	6	1,002	120	5	595	105	3,730	557
1988	10	1,940	310	1	193	22	6	1,002	120	5	595	105	3,730	557
1989	10	1,940	310	1	193	22	6	1,002	120	5	595	105	3,730	557
1990	10	1,940	310	1	193	22	6	1,002	120	6	714	126	3,849	578
1991	10	1,940	310	1	193	22	6	1,002	120	6	714	126	3,849	578
TOTAL	89	17,266	2,759	11	2,123	242	49	8,183	980	50	5,950	1,050	33,522	5,031

Table 4-4. 2/3 Traffic Model
(1977 K$ - Manpower Costs)

OPTION A-3

	ATL			LIFE SCIENCE			COMB. ASTRON.			SP PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	224	41	-	-	-	-	-	-	-	-	-	224	41
1981	3	672	123	1	212	31	-	-	-	2	246	42	1,130	196
1982	3	672	123	1	212	31	1	207	32	1	123	21	1,214	207
1983	5	1,120	205	1	212	31	3	621	96	5	615	105	2,568	437
1984	7	1,568	287	1	212	31	3	621	96	5	615	105	3,016	519
1985	10	2,240	410	1	212	31	6	1,242	192	5	615	105	4,309	738
1986	10	2,240	410	1	212	31	6	1,242	192	5	615	105	4,309	738
1987	10	2,240	410	1	212	31	6	1,242	192	5	615	105	4,309	738
1988	10	2,240	410	1	212	31	6	1,242	192	5	615	105	4,309	738
1989	10	2,240	410	1	212	31	6	1,242	192	5	615	105	4,309	738
1990	10	2,240	410	1	212	31	6	1,242	192	6	738	126	4,432	759
1991	10	2,240	410	1	212	31	6	1,242	192	6	738	126	4,432	759
TOTAL	89	19,936	3,649	11	2,332	341	49	10,143	1,568	50	6,150	1,050	38,561	6,608

Table 4-5. 2/3 Traffic Model
(1977 K$ - Manpower Costs)

OPTION B-1

	ATL			LIFE SCIENCE			COMB. ASTRON.			SP PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	200	39	-	-	-	-	-	-	-	-	-	200	39
1981	3	600	117	1	163	34	-	-	-	2	248	56	1,011	207
1982	3	600	117	1	163	34	1	174	26	1	124	28	1,061	205
1983	5	1,000	195	1	163	34	3	522	78	5	620	140	2,305	447
1984	7	1,400	273	1	163	34	3	522	78	5	620	140	2,705	525
1985	10	2,000	390	1	163	34	6	1,044	156	5	620	140	3,827	720
1986	10	2,000	390	1	163	34	6	1,044	156	5	620	140	3,827	720
1987	10	2,000	390	1	163	34	6	1,044	156	5	620	140	3,827	720
1988	10	2,000	390	1	163	34	6	1,044	156	5	620	140	3,827	720
1989	10	2,000	390	1	163	34	6	1,044	156	5	620	140	3,827	720
1990	10	2,000	390	1	163	34	6	1,044	156	6	744	168	3,951	748
1991	10	2,000	390	1	163	34	6	1,044	156	6	744	168	3,951	748
TOTAL	89	17,800	3,471	11	1,793	374	49	8,526	1,274	50	6,200	1,400	34,319	6,519

Table 4-6. 2/3 Traffic Model
(1977 K$ - Manpower Costs)

OPTION B-4

	ATL			LIFE SCIENCE			COMB. ASTRON.			SP PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	202	49	-	-	-	-	-	-	-	-	-	202	49
1981	3	606	147	1	158	35	-	-	-	2	256	56	1,020	238
1982	3	606	147	1	158	35	1	170	37	1	128	28	1,062	247
1983	5	1,010	245	1	158	35	3	510	111	5	640	140	2,318	531
1984	7	1,414	343	1	158	35	3	510	111	5	640	140	2,722	629
1985	10	2,020	490	1	158	35	6	1,020	222	5	640	140	3,838	887
1986	10	2,020	490	1	158	35	6	1,020	222	5	640	140	3,838	887
1987	10	2,020	490	1	158	35	6	1,020	222	5	640	140	3,838	887
1988	10	2,020	490	1	158	35	6	1,020	222	5	640	140	3,838	887
1989	10	2,020	490	1	158	35	6	1,020	222	5	640	140	3,838	887
1990	10	2,020	490	1	158	35	6	1,020	222	6	768	168	3,966	915
1991	10	2,020	490	1	158	35	6	1,020	222	6	768	168	3,966	915
TOTAL	89	17,978	4,361	11	1,738	385	49	8,330	1,813	50	6,400	1,400	34,446	7,959

Table 4-7. 2/3 Traffic Model
(1977 K$ - Manpower Costs)

OPTION C-1

	ATL			LIFE SCIENCE			COMB. ASTRON.			SP PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	206	58	-	-	-	-	-	-	-	-	-	206	58
1981	3	618	174	1	169	53	-	-	-	2	260	86	1,047	313
1982	3	618	174	1	169	53	1	181	62	1	130	43	1,098	332
1983	5	1,030	290	1	169	53	3	543	186	5	650	215	2,392	744
1984	7	1,442	406	1	169	53	3	543	186	5	650	215	2,804	860
1985	10	2,060	580	1	169	53	6	1,086	372	5	650	215	3,965	1,220
1986	10	2,060	580	1	169	53	6	1,086	372	5	650	215	3,965	1,220
1987	10	2,060	580	1	169	53	6	1,086	372	5	650	215	3,965	1,220
1988	10	2,060	580	1	169	53	6	1,086	372	5	650	215	3,965	1,220
1989	10	2,060	580	1	169	53	6	1,086	372	5	650	215	3,965	1,220
1990	10	2,060	580	1	169	53	6	1,086	372	6	780	258	4,095	1,263
1991	10	2,060	580	1	169	53	6	1,086	372	6	780	258	4,095	1,263
TOTAL	89	18,334	5,162	11	1,859	583	49	8,869	3,038	50	6,500	2,150	35,562	10,933

Table 4-8. 2/3 Traffic Model
(1977 K$ - Manpower Costs)

OPTION C-4

	ATL			LIFE SCIENCE			COMB. ASTRON.			SP PROCESSING				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	209	76	-	-	-	-	-	-	-	-	-	209	76
1981	3	627	228	1	168	56	-	-	-	2	268	88	1,063	372
1982	3	627	228	1	168	56	1	176	60	1	134	44	1,105	388
1983	5	1,045	380	1	168	56	3	528	180	5	670	220	2,411	836
1984	7	1,463	532	1	168	56	3	528	180	5	670	220	2,829	988
1985	10	2,090	760	1	168	56	6	1,056	360	5	670	220	3,984	1,396
1986	10	2,090	760	1	168	56	6	1,056	360	5	670	220	3,984	1,396
1987	10	2,090	760	1	168	56	6	1,056	360	5	670	220	3,984	1,396
1988	10	2,090	760	1	168	56	6	1,056	360	5	670	220	3,984	1,396
1989	10	2,090	760	1	168	56	6	1,056	360	5	670	220	3,984	1,396
1990	10	2,090	760	1	168	56	6	1,056	360	6	804	264	4,118	1,440
1991	10	2,096	760	1	168	56	6	1,056	360	6	804	264	4,118	1,440
TOTAL	89	18,601	6,764	11	1,848	616	49	8,624	2,940	50	6,700	2,200	35,773	12,520

GSE REQUIREMENTS - 2/3 TRAFFIC MODEL

In this section, the GSE quantities and costs associated with the reduced flight rates of the 2/3 Traffic Model are presented. The GSE sets required for this traffic model are presented in the previous section as follows:

Life Science Payload - Tables 3-19 through 3-31

Combined Astronomy Payload - Tables 3-32 through 3-37

Space Processing Payload - Tables 3-38 through 3-39

Advanced Technology Laboratory Payload - Tables 3-40 through 3-45

In order to establish the GSE resource spending requirements for the reduced flight rate associated with the 2/3 Traffic Model, the methodology described above under Programmatic GSE Assessment was applied for the new flight rate, and a new set of year-by-year expenditure charts prepared for each payload and processing option. These are presented herein as Tables 4-9 through 4-14. As in "GSE Requirements" in section 3, a final summary table also escalating the cost figures is then presented as Table 4-15.

In reviewing the summary data by option, it is evident that GSE costs decrease significantly from the minicenter approach to lead center, and further from lead center to KSC. This is due to increased sharing and utilization of the GSE. In the distributed concept, there is considerable duplication of GSE between minicenters (15 minicenters for the four payloads). This duplication is largely eliminated at the lead centers where a single set for the payload being integrated is used - a maximum of 4 sets of GSE with only partial duplication for common usage items. In the case of KSC integration, this is reduced even further because of sharing one common GSE set between payloads. These cost differentials are due not only to a need for more GSE as integration sites are distributed, but also an increase in transportation costs required to ship GSE from and to the KSC depot in the lead center and distributed cases. This effort is evident when comparing the total GSE costs between A-1, B-1 and C-1, and between B-4 and C-4 options.

The primary effect and difference between the results of studying this Traffic Model and the Baseline model is, of course, lower expenditures for GSE. Since a basic set of GSE is still required for each payload, the reduction is not all proportional to the reduction in flight rates, but is evident that fewer second GSE sets are required, and NO third GSE sets are required.

Table 4-9 . Annual GSE Expenditures - 2/3 Traffic Model
(1977 $K)

OPTION A-1

YEAR	KSC	LIFE SCIENCE								ATL			COMB. ASTRON.			SP	TOTALS	
		1	2	3	4	5	6	7	8	1	2	3	1	2	3	1	DIRECT	+ SPARES
1979										585	187.5	592.5					1365	1638
1980		344	364	199	185	185	315	185	424							513.5	2714.5	3257.4
1981													628.5	817	571.5		2017	2420.4
1982																		
1983										273		251					524	628.8
1984										2T		2T						
1985																		
1986																		
1987																		
1988																		
1989																		
1990																		
1991																		
TOTAL		344	364	199	185	185	315	185	424	858	187.5	843.5	628.5	817	571.5	513.5	6620.5	7944.6

Table 4-10. Annual GSE Expenditures - 2/3 Traffic Model
(1977 $K)

OPTION A-3

YEAR	KSC	LIFE SCIENCE								ATL			COMB.ASTRO.			SP	TOTALS	
		1	2	3	4	5	6	7	8	1	2	3	1	2	3	1	DIRECT	+ SPARES
1979	342.5									585	187.5	592.5					1365	1638
1980		344	364	199	185	185	315	185	424							513.5	2714.5	3257.4
1981													628.5	817	571.5		2017	2420.4
1982																		
1983										273		251					524	628.8
1984										2T	59	2T					59	70.8
1985											2T		236.5	458			694.5	833.4
1986													2T	2T				
1987																		
1988																		
1989																		
1990																		
1991																		
TOT.		344	364	199	185	185	315	185	424	858	246.5	843.5	865	1275	571.5	513.5	7374	8848.8

Table 4-11. Annual GSE Expenditures - 2/3 Traffic Model
(1977 $K)

OPTION B-1

YEAR	LIFE SCIENCE	ATL-A	COMBINED ASTRONOMY	SPACE PROCESSING	TOTALS DIRECT	TOTALS + SPARES
1979		693.5			693.5	832.2
1980	585			513.5	1098.5	1318.2
1981			1042.5		1042.5	1251.0
1982						
1983		324.5			324.5	389.4
1984		2T				
1985						
1986						
1987						
1988						
1989						
1990						
1991						
TOTAL	585	1018	1042.5	513.5	3159.0	3790.8

Table 4-12. Annual GSE Expenditures - 2/3 Traffic Model
(1977 $K)

OPTION B-4

YEAR	LIFE SCIENCE	ATL-A	COMBINED ASTRONOMY	SPACE PROCESSING	TOTALS DIRECT	TOTALS + SPARES
1979		658.5			658.5	790.2
1980	470.5			513.5	984.0	1180.8
1981			1009.5		1009.5	1211.4
1982						
1983		289.5			289.5	347.4
1984		2T				
1985			650.5		650.5	780.6
1986			2T			
1987						
1988						
1989		369.0			369.0	442.8
1990		2P				
1991						
TOTAL	470.5	1317.0	1660.0	513.5	3961.0	4753.2

Table 4-13. Annual GSE Expenditures - 2/3 Traffic Model
(1977 $K)
Combined KSC GSE Set

OPTION C-1

YEAR	PROCESSING GSE	TRANSPORTATION GSE	TOTAL DIRECT	TOTAL WITH SPARES
1979	369.0	324.5	693.5	832.0
1980	76.0	135.5	211.5	254.0
1981	51.0	369.5	420.5	505.0
1982	496.0		496.0	596.0
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
TOTAL	992.0	829.5	1821.5	2187.0

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Table 4-14. Annual GSE Expenditures - 2/3 Traffic Model
(1977 $K)
Combined KSC GSE Set

OPTION C-4

YEAR	PROCESSING GSE	TRANSPORTATION GSE	TOTAL DIRECT	TOTAL WITH SPARES
1979	369.0	289.5	658.5	790.0
1980	76.0	14.5	90.5	109.0
1981	50.0	401.0	451.0	541.0
1982	495.0		495.0	594.0
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
TOTAL	990.0	704.5	1694.5	2034.0

Table 4-15. GSE Cost Summary - 2/3 Traffic Model

		79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
1977 DOLLARS	A-1	1638	3257	2420		629									7944
	A-3	2049	2977	2420		629	71	833							8979
	B-1	832	1318	1251		389									3790
	B-4	790	1181	1211		347		781				443			4753
	C-1	832	254	505	596										2187
	C-4	790	109	541	594										2034
ESCALATED DOLLARS	A-1	1876	3990	3173		944									9983
	A-3	2346	3647	3173		944	114	1431							11655
	B-1	953	1615	1640		584									4792
	B-4	905	1447	1588		521		1342				998			6801
	C-1	953	311	662	836										2762
	C-4	905	134	709	833										2581

SPACELAB FLIGHT HARDWARE REQUIREMENTS (2/3 BASELINE TRAFFIC MODEL)

Spacelab Flight Hardware Element Evaluated

The Spacelab flight hardware elements analyzed for the baseline traffic model were also utilized to determine the quantities required to support the 2/3 Baseline Traffic model. The elements evaluated are contained in Table 4-16. Their costs in millions of 1977 dollars are also listed. These costs were supplied as a study input by NASA.

Table 4-16. Spacelab Flight Hardware Items

ELEMENT	COST (1977 $M)	ELEMENT	COST (1977 $M)
Core Module	35.0	Rack - Single	0.179
Igloo	10.0	- Double	0.229
IPS	10.0	EPDB	0.088
SIPS	1.5	Floor Segment	0.039
Pallet Segment	3.022	Cold Plate	0.027
RAU	0.143		

The same methodology employed with the Baseline Traffic model analysis was used again in this traffic model sensitivity analysis. Principally, the three major factors that establish programmatically the quantities required to support each option evaluated are:

- Involvement time of the Spacelab flight hardware in ground processing flows of each option
- Quantities required for a given payload configuration
- Flight rate and launch schedule of the Payload configuration for any given year of the traffic model.

The configuration dependent Spacelab Flight Hardware and items are illustrated in Table 4-17.

Table 4-17. Payload Spacelab Flight Hardware Requirements

SPACELAB HARDWARE ELEMENT	PAYLOAD			
	SIP	C/A	L/S	ATL
Core Module	-	-	1	1
Igloo	1	1	-	-
IPS	-	1	-	-
SIPS	-	1	-	-
Pallet Segment	1	5	-	2
RAU	1	9	4	4
Racks-Single	-	-	4	2
Racks-Double	-	-	6	2
EPDB	1	5	3	3
Floor Segment	-	-	3	1
Cold Plates	4	5	-	4

Of these eleven hardware end items the first four are not as option dependent as they are configuration dependent. It has been determined both by previous NASA studies (Core Module and Igloo) and by the system level trades (IPS and SIPS - see section 2.0 of this volume) that the end items would remain at KSC and would not be involved in the Spacelab Level IV integration activities. Therefore, the quantities of these hardware end items required to support a given traffic model are equal across the options evaluated in this study.

The annual flight rate of each of the payloads of the 2/3 baseline traffic model is shown in Table 4-18. The launch dates of each of these missions are defined in the payload equivalency analysis that is defined in the section entitled, "Traffic Model Analysis."

Table 4-18. 2/3 Baseline Traffic Model

PAYLOAD	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
Life Science	-	1	1	1	1	1	1	1	1	1	1	1
ATL	1	3	3	5	7	10	10	10	10	10	10	10
Combined Astronomy	-	-	1	3	3	6	6	6	6	6	6	6
Space Processing	-	2	1	5	5	5	5	5	5	5	6	6
Totals	1	6	6	14	16	22	22	22	22	22	23	23

Derivation of Flight Hardware Quantities

The quantity of Core Modules required to support all options of the 2/3 baseline traffic model is shown on Table 4-19. The Core Modules are required to support the habitable module flights; therefore, only the launch rate and schedule of the ATL and Life Science missions are a driver on the required program totals of Core Modules. As discussed in section 3.0 under "Spacelab Flight Hardware Requirements" at the present KSC assessed serial ground processing times a single Core Module can support up to six flights per year (given the launches are at least 42 days apart). Therefore, from Table 4-19 it can be seen that the second core module is not required until 1984 when the combined launch rate (LS + ATL) reaches eight flights. Since the capability of two Core Modules is up to 12 flights per year (given a minimum of 21 day intervals between flights), the second Core Module can meet the program requirements of 11 missions per year. The table also lists the percentage utilization of each of the Core Modules. For example in 1983 when there are six habitable module flights scheduled the Core Module is being utilized some 95.1% of its available time, 247.2 days out of a potential 260 working days per year. At the eleven flights per year rate each Core Module is utilized an average of 87.5 percent of the available time.

Table 4-19. Core Module Requirements for all Options (2/3 Baseline Traffic Model)

YEAR	FLIGHTS			TOTAL PROCESSING DAYS	UNITS REQ'D	% UTIL.
	LS	ATL	TOTAL			
1980	-	1	1	71	1	27.0
1981	1	3	4	189.0		72.7
1982	1	3	4	164.0		63.0
1983	1	5	6	247.2		95.1
1984	1	7	8	330.4	2	63.5
1985	1	10	11	455.2		87.5
1986	1	10	11			
1987	1	10	11			
1988	1	10	11			
1989	1	10	11			
1990	1	10	11			
1991	1	10	11			

The igloo requirements for all options of the 2/3 baseline traffic model are illustrated in Table 4-20. The IPS and SIPS requirements for all options are also shown on Table 4-20. The study ground rule used in the determination of the final SIPS and IPS program totals is that in the case of SIPS there would be an additional flight unit added to accommodate those missions planned to fly with two SIPS. The IPS quantity requirements were modified by the ground rule that the IPS would only be used on every other Combined Astronomy type mission.

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Table 4-20. Igloo, IPS, and SIPS Requirements for all Options (Baseline Traffic Model)

	FLTS							SIPS and IPS			
YR	CA	SP	TOTAL	Igloo Units Req'd	Total Proc. Days	% Util.	Total Proc CA	SIPS	% Util	IPS	% Util
1980	-	-	-								
1981	-	2	2	1	68.4	26.3		1+1	14.3	1	7.2
1982	1	1	2		68.4	26.3	37.2		42.9		21.5
1983	3	5	8	2	273.6	52.6	111.6		42.9		21.5
1984	3	5	8			52.6			85.8		42.9
1985	6	5	11		376.2	72.3	223.2				
1986	6	5	11								
1987	6	5	11								
1988	6	5	11								
1989	6	5	11								
1990	6	6	12		410.4	78.9					
1991	6	6	12		410.4						

Spacelab Flight Hardware Requirements by Option

The following sections will define those hardware quantities that are option dependent. These items are: Racks (double and single), Pallet Segments, RAU's, Cold Plates, Floor Segments, and EPDB's. The following six tables 4-21 through 4-26 contain the Rack and Pallet requirements for each of the six options evaluated in the study.

Table 4-21. Option A-1 Rack and Pallet Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RACKS	2S 2D				4S 4D	6S 6D						
PALLETS	2			4	6	8						
• LS												
RACKS		4S 6D										
• C/A												
PALLETS			5			10						
• S/P												
PALLETS		1		2								
• TOTAL												
RACKS	2S 2D	6S 8D	6S 8D	6S 8D	8S 10D	10S 12D						10S 12D
PALLETS	2	3	8	11	13	20						20

Table 4-22. Option A-3 Rack and Pallet Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RACKS	2S 2D				4S 4D	6S 6D						
PALLETS	2			4	6	8						
• LS												
RACKS		4S 6D										
• C/A												
PALLETS			5	10								
• S/P												
PALLETS		1		2								
• TOTAL												
RACKS	2S 2D	6S 8D	6S 8D	6S 8D	8S 10D	10S 12D						10S 12D
PALLETS	2	3	8	16	18	20						20

Table 4-23. Option B-1 Rack and Pallet Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RACKS	2S 2D				4S 4D	6S 6D						
PALLETS	2			4	6	8						
• LS												
RACKS		4S 6D										
• C/A												
PALLETS			5			10						
• S/P												
PALLETS		1		2								
• TOTAL												
RACKS	2S 2D	6S 8D			8S 10D	10S 12D						10S 12D
PALLETS	2	3	8	11	13	20						20

Table 4-24. Option B-4 Rack and Pallet Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RACKS	2S 2D				4S 4D	6S 6D						
PALLETS	2			4	6	8						
• LS												
RACKS		4S 6D										
• C/A												
PALLETS			5			10						
• S/P												
PALLETS		1		2								
• TOTAL												
RACKS	2S 2D	6S 8D			8S 10D	10S 12D						10S 12D
PALLETS	2	3	8	11	13	20						20

Table 4-25. Option C-1 Rack and Pallet Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RACKS	2S 2D				4S 4D							
PALLETS	2			4	6							
• LS												
RACKS		4S 6D										
• C/A												
PALLETS			5			10						
• S/P												
PALLETS		1		2								
• TOTAL												
RACKS	2S 2D	6S 8D	6S 8D	6S 8D	8S 10D							8S 10D
PALLETS	2	3	8	11	13	18						18

Table 4-26. Option C-4 Rack and Pallet Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RACKS	2S 2D				4S 4D						6S 6D	
PALLETS	2			4	6						8	
• LS												
RACKS		4S 6D										
• C/A												
PALLETS			5			10						
• S/P												
PALLETS		1		2								
• TOTAL												
RACKS	2S 2D	6S 8D			8S 10D					8S 10D	10S 12D	10S 12D
PALLETS	2	3	8	11	13	18				18	20	20

Five of the six options required the same amount of flight hardware - 10 single racks, 12 double racks, and 20 pallet segments. The years in which these quantities were required varied only slightly. Option A-3 required 16 of its 20 pallets in the fourth year of the program (1983) while the other five options could meet the launch schedules with 13 pallets until the sixth year of the program. Because of its shorter ground processing flow times option C-1 had the smallest flight hardware requirements. This option could meet the total 2/3 baseline traffic model with 18 racks (8 single, 10 double) instead of 22, and with 18 pallet segments rather than 20 as required by the other five options. Option C-4 has almost the same hardware requirements as C-1 with the exception of during the last two years of the program when the flight rate goes from 21 missions per year to 22. This option requires an additional two single and two double racks plus two more pallet segments to its inventory. But for the first ten years of the program both Options C-1 and C-4 have identical Spacelab flight hardware requirements.

The following six tables 4-27 through 4-32 list the RAU, Cold Plate, and Floor Segment requirements for each of the six options. Option A-3, because of its longer processing times, required the most RAU's, Cold Plates, and Floor Segments 40, 34, and 6 respectively.

Table 4-27. Option A-1 RAU, Cold Plate and Floor Segment Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RAU's	4			8		12						
Cold Plates	4			8		12						
Floor Segment	3			2		3						
• LS												
RAU's		4										
Floor Segment		2										
• CA												
RAU's			9			18						
Cold Plates			5			10						
• SP												
RAU's		1		2								
Cold Plates		4		8								
• Total												
RAU's	4	9	18	23	23	36	←				→	36
Cold Plates	4	8	13	21	21	30	←				→	30
Floor Segment	1	3	3	4	4	5	←				→	5

Table 4-28. Option A-3 RAU, Cold Plate and Floor Segment Requirements (2/3 Traffic Model)

OPTION	YEAR 80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RAU's	4			8	12	16						
Cold Plates	4			8	12	16						
Floor Segment	1			2	3	4						
• LS												
RAU's		4										
Floor Segment		2										
• CA												
RAU's			9			18						
Cold Plates			5			10						
• SP												
RAU's		1	2									
Cold Plates		4	8									
• Total												
RAU's	4	9	18	23	27	40	←				→	40
Cold Plates	4	8	13	21	25	34	←				→	34
Floor Segment	1	3	3	4	5	6	←				→	6

Table 4-29. Option B-1 RAU, Cold Plate and Floor Segment Requirements (2/3 Traffic Model)

OPTION	YEAR 80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RAU's	4			8	12							
Cola Plares	4			8	12							
Floor Segment	1			2	3							
• LS												
RAU's		4										
Floor Segment		2										
• CA												
RAU's			9			18						
Cold Plates			5			10						
• SP												
RAU's		1		2=								
Cold Plates		4		8								
• Total												
RAU's	4	9	18	23	27	36	←				→	36
Cold Plates	4	8	13	21	25	30	←				→	30
Floor Segment	1	3	3	4	5		←				→	5

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Table 4-30. Option B-4 RAU, Cold Plate and Floor Segment Requirements
(2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RAU's	4			8	12							
Cold Plates	4			8	12							
Floor Segment	1			2	3							
• LS												
RAU's		4										
Floor Segment		2										
• CA												
RAU's			9			18						
Cold Plates			5			10						
• SP												
RAU's		1		2								
Cold Plates		4		8								
• Total												
RAU's	4	9	18	23	27	36						36
Cold Plates	4	8	13	21	25	30						30
Floor Segment	1	3	3	4	5							5

Table 4-31. Option C-1 RAU, Cold Plate and Floor Segment Requirements
(2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RAU's	4			8		12						
Cold Plates	4			8		12						
Floor Segment	1			2		3						
• LS												
RAU's		4										
Floor Segment		2										
• CA												
RAU's			9			18						
Cold Plates			5			10						
• SP												
RAU's		1		2								
Cold Plates		4		8								
• Total												
RAU's	4	9	18	23	23	36						36
Cold Plates	4	8	13	21	21	30						30
Floor Segment	1	3	3	4	4	5						5

Table 4-32. Option C-4 RAU, Cold Plate and Floor Segment Requirements (2/3 Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
• ATL												
RAU's	4			8		12						
Cold Plates	4			8		12						
Floor Segment	1			2		3						
• LS												
RAU's		4										
Floor Segment		2										
• CA												
RAU's			9			18						
Cold Plates			5			10						
• SP												
RAU's		1		2								
Cold Plates		4		8								
• Total												
RAU's	4	9	18	23	23	36	←				→	36
Cold Plates	4	8	13	21	21	30	←				→	30
Floor Segment	1	3	3	4	4	5	←				→	5

The Electrical Power Distribution Boxes required to support the 2/3 Baseline Traffic model are driven both by the configuration requirements of each payload as well as by the option being evaluated. Table 4-33 contains the number of EPDB's required by each option.

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Table 4-33. EPDB Requirements for all Options (2/3 Baseline Traffic Model)

OPTION	YEAR											
	1980	81	82	83	84	85	86	87	88	89	90	91
A-1	3	6	11	14	17	25						25
A-3	3	6	11	19	22	25						25
B-1	3	6	11	14	17	25						25
B-4	3	6	11	14	17	25						25
C-1	3	6	11	14	17	22						22
C-4	3	6	11	14	17	22					25	25

- EPDB Requirements per configuration: One/Pallet, One per Core Segment, Two per Experiment Segment

	CS	ES	P	Total
ATL	1	-	2	3
LS	1	2	-	3
CA	-	-	5	5
SP	-	-	1	1

Option C-1 requires the least amount (25) of EPDB's to support the 2/3 Baseline traffic model. All other options require 25 to meet the 199 missions of the traffic model. Option C-4, however, does not need the last three EPDB's until the eleventh year of the program. Therefore, in this category for the first ten years of the program both Options C-1 and C-4 require the fewest number of EPDB's to support the traffic model.

Spacelab Flight Hardware Cost Summaries

The following six Tables 4-34 through 4-39 summarize the Spacelab Flight hardware costs, including the year those costs were incurred, for each of the six program options evaluated. The costs of each hardware end item (study input) were allocated in the year preceding their first usage; that is, if a pallet segment were required in an option in 1984 the costs for that pallet were added to the total in 1983 in anticipation of first usage. Included in each table are the costs of each end item in 1977 dollars and also the escalated annual totals. The escalation utilized for Spacelab flight hardware is a 10% annual factor.

Option C-1 has the lowest total cost for Spacelab flight hardware with a cost of \$166.207M (1977 dollars). The highest option is the distributed option A-3 with the combined P/L C/O (prior to Level III/II operations). The A-3 costs are \$74.050M.

Table 4-34. Spacelab Hardware Costs (1977 $M)
(2/3 Traffic Model)

OPTION A-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.1795 .2290	3.022	.143	.039	027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.716 1.374	3.022	.715	.078	.108	.264	6.277	8 355
1981		15.110	1.287		.135	.440	16.972	24.847
1982		9.066	.715	.039	.216	.264	10.300	16.593
1983	.358 .458	6.044				.264	7.124	12.624
1984	.358 .458	21.154	1.859	.039	.243	.704	24.815	48.364
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.790 2 748	60.44	5.148	195	810	2.200	73.331	120.273

Table 4-35. Spacelab Hardware Costs (1977 $M)
(2/3 Traffic Model)

OPTION A-3	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.1795 .2290	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.716 1.374	3.022	.715	.078	108	.264	6.277	8.355
1981		15.110	1.287		.135	.440	16.972	24.847
1982		24.176	.715	.039	.216	.704	25.850	41.644
1983	.358 .458	6.044	.572	.039	.108	.264	7.843	13.897
1984	.358 .458	6.044	1.859	.039	.243	.264	9.265	18.057
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.790 2.748	60.44	5.720	.234	.918	2.200	74.050	116.291

Table 4-36. Spacelab Hardware Costs (1977 $M)
(2/3 Traffic Model)

OPTION B-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.716 1.374	3.022	.715	.078	.108	.264	6.277	8.355
1981		15.110	1.287		.135	.440	16.972	24.847
1982		9.066	.715	.039	.216	.264	10.300	16.593
1983	.358 .458	6.044	.572	.039	.108	264	7.843	13.898
1984	.358 .458	21.154	1.287		.135	.704	24.096	46.963
1985							- -	- -
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.790 2.748	60.44	5.148	.195	.810	2.200	73.331	120.146

Table 4-37. Spacelab Hardware Costs (1977 $M)
(2/3 Traffic Model)

OPTION B-4	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.716 1.374	3.022	.715	.078	.108	.264	6.277	8.355
1981		15.110	1.287		.135	.440	16.972	24.847
1982		9.066	.715	.039	.216	.264	10.300	16.593
1983	.358 458	6 044	.572	.039	.108	.264	7.843	13.898
1984	.358 .458	21.154	1.287		.135	.704	24.096	46 963
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.790 2.748	60.440	51.48	.195	.810	2.200	73.331	120.146

Table 4-38. Spacelab Hardware Costs (1977 $M)
(2/3 Traffic Model)

OPTION C-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.716 1.374	3.022	.715	.078	.108	.264	6.277	8.355
1981		15.110	1.287		.135	.440	16 972	24.847
1982		9.066	.715	.039	.216	.264	10.300	16.593
1983	.358 .458	6.044		.		.264	7.124	12.624
1984		15.110	1.859	.039	.243	.440	17.691	34.480
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.432 2.290	54.396	5.148	.195	.810	1.936	66.207	106 389

Table 4-39. Spacelab Hardware Costs (1977 $M)
(2/3 Traffic Model)

OPTION C-4	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7 843	9.490
1980	.716 1.374	3.022	.715	.078	.108	.264	6.277	8.355
1981		15.110	1.287		.135	.440	16 972	24.847
1982		9.066	.715	.039	.216	.264	10.300	16.593
1983	.358 .458	6.044			.	.264	7 124	12.624
1984		15.110	1.859	.039	243	.440	17.691	34.480
1985								
1986								
1987								
1988								
1989								
1990								
1991	.358 .458	6.044				.264	7.124	27.050
TOTALS	1.790 2.748	60.440	5.148	.195	.810	2.200	77.331	133.438

TRANSPORTATION COSTS

Transportation Factors

The transportation factors are identical to those discussed in Section 3 "Transportation Factors" of this volume. The same type vehicle requirements exist, the same costing factors and the same transportation times; however, these factors are balanced against the 2/3 traffic model.

For details as to these factors, refer to the appropriate discussions in Section 3.0

Transportation Requirements

Similarly as with the "Transportation Factors" discussed above, transportation requirements remain the same for the 2/3 traffic model. The cost of shipment of Spacelab flight and GSE hardware to/from Level IV integration sites other than at KSC were predicated upon the total number of end items and the width of the shipment. Shipments requiring an out-sized carrier - greater than 8 feet in width - required five working days and cost $4000. Standard shipments of 8 foot in width were assumed to require two days and cost $3000. Shipments within the KSC complex were assumed to require one day and cost $1000.

In Section 3.0, Tables 3-82 thru 3-85 summarize the transportation/shipment requirements and costs for each payload and their applicable processing options. Distributed site options are the most costly because of the duplication of out-sized carrier shipments. Lead center option costs reflect the feasibility of multiple out-sized elements contained in one shipment. As expected, KSC shipment costs are minimal.

Optimum Transportation Costs - 2/3 Traffic Model

The following six tables, Table 4-40 through 4-45, are summaries of the transportation costs of the six options studied in detail: A-1, A-3, B-1, B-4, C-1 and C-4. Each of the tables summarize the studied options for each year and for the twelve year duration of the 2/3 mission model.

Table 4-40. 2/3 Traffic Model

OPTION· A-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	--	--	42	126	126	252	252	252	252	252	252	252	2058
Space Processing		30	15	75	75	75	75	75	75	75	90	90	750
Life Science	--	70	70	70	70	70	70	70	70	70	70	70	770
Advanced Technology	34	102	102	170	238	340	340	340	340	340	340	340	3026
TOTALS ($)	34	172	214	366	434	662	662	662	662	662	662	662	6604

Table 4-41. 2/3 Traffic Model

OPTION. A-3	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	--	--	45	135	135	270	270	270	270	270	270	270	2205
Space Processing	--	30	15	75	75	75	75	75	75	75	90	90	750
Life Science	--	70	70	70	70	70	70	70	70	70	70	70	770
Advanced Technology	34	102	102	170	238	340	340	340	340	340	340	340	3026
TOTALS ($)	34	202	232	450	518	755	755	755	755	755	770	770	6751

Table 4-42. 2/3 Traffic Model

OPTION B-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	--	--	22	66	66	132	132	132	132	132	132	132	1078
Space Processing	--	30	15	75	75	75	75	75	75	75	90	90	750
Life Science	--	17	17	17	17	17	17	17	17	17	17	17	187
Advanced Technology	14	42	42	70	98	140	140	140	140	140	140	140	1246
TOTALS ($)	14	85	96	228	256	289	289	289	289	289	289	289	3261

Table 4-43. 2/3 Traffic Model

OPTION. B-4	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	--	--	22	66	66	132	132	132	132	132	132	132	1078
Space Processing	--	30	15	75	75	75	75	75	75	75	90	90	750
Life Science	--	17	17	17	17	17	17	17	17	17	17	17	187
Advanced Technology	14	42	42	70	98	140	140	140	140	140	140	140	1246
TOTALS ($)	14	89	96	228	256	364	364	364	364	364	379	379	3261

Table 4-44. 2/3 Traffic Model

OPTION. C-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	--	--	3	9	9	18	18	18	18	18	18	18	147
Space Processing	--	8	4	20	20	20	20	20	20	20	24	24	200
Life Science	--	3	3	3	3	3	3	3	3	3	3	3	33
Advanced Technology	3	9	9	15	21	30	30	30	30	30	30	30	267
TOTALS ($)	3	20	19	47	53	71	71	71	71	71	75	75	647

Table 4-45. 2/3 Traffic Model

OPTION. C-4	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	--	--	-	3	9	9	18	18	18	18	18	18	129
Space Processing	--	--	8	4	20	20	20	20	20	20	24	24	180
Life Science	--	3	3	3	3	3	3	3	3	3	3	3	33
Advanced Technology	3	9	9	15	21	30	30	30	30	30	30	30	267
TOTALS	3	12	20	25	53	62	71	71	71	71	75	75	609

A summary table has been generated which details the various options studied with regard to the 2/3 Traffic Model based on the four study payloads, Table 4-46.

OPTION. The options which were studied in detail are A-1, A-3, B-1, B-4, C-1 and C-4. There is no option A-3 for Space Processing; however, option A-2 was studied in its place.

YEAR. The model time span was a 12-year period scheduled from 1980 through 1991.

COST PER FLIGHT-BASELINE. These are the costs in thousands of dollars as established in the section entitled "Transportation Requirements".

NUMBER OF FLIGHTS. For each payload studied, a total number of flights are identified based on the 2/3 Traffic Model for each year.

TOTAL TRANSPORTATION COSTS. The dollar amount in this column is a result of multiplying the number of flights times the transportation costs per flight (i.e., in 1984 there are 10 flights scheduled X 34(000) dollars = 340(000) dollars).

ALL PAYLOADS TOTAL. This is an accumulation of each payloads' Total Transportation Cost column.

INFLATION FACTOR. An inflation factor was calculated for each of the years in the mission timeline based on an annual 7% compounded rate.

INFLATED COSTS. These are the final escalated transportation costs calculated by multiplying the straight totals by the inflation factor.

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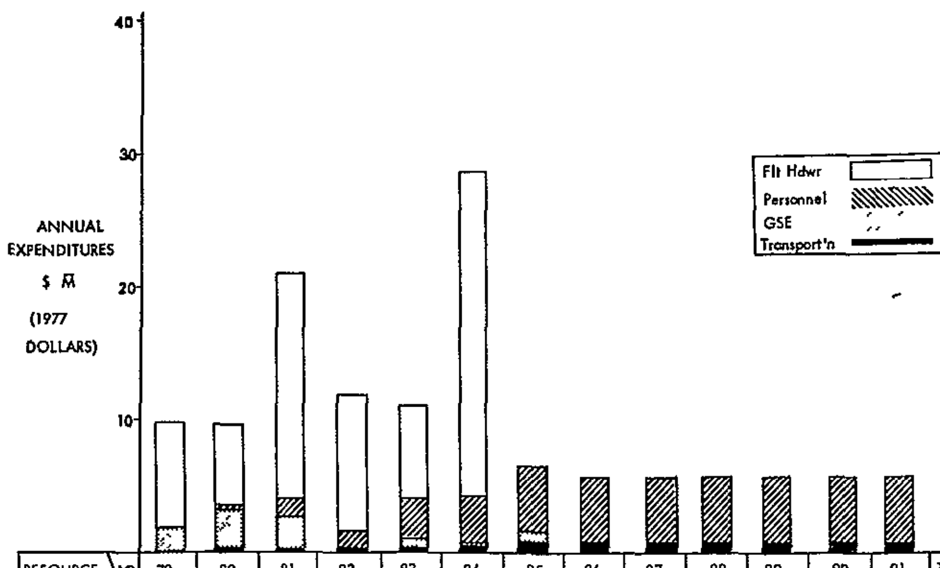
Table 4-46. Transportation Costs
(2/3 Traffic Model)

PAYLOAD →		2/3 TRAFFIC MODEL: ATL			CA			LS			SP			TOTALS		
OPTION	YEAR	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	ALL TOTAL	INFLATION FACTOR	INFLATED COST
	1980		1	34		-	-		-	-		-	-	34	1 225	41,65
	1981		3	102		-	-		1	70		2	30	202	1 311	264,82
	1982		3	102		1	42					1	15	229	1 403	321,29
	1983		5	170		3	126					5	75	441	1 501	661 94
	1984		7	238		3	126					5	75	509	1 606	817,45
A-1	1985	34	10	340	42	6	252	70			15	5	75	737	1,718	1266,17
	1986		10	340		6	252					5	75	737	1,838	1354 61
	1987		10	340		6	252					5	75	737	1,967	1449 68
	1988		10	340		6	252					5	75	737	2,105	1551,39
	1989		10	340		6	252					5	75	737	2,252	1659,72
	1990		10	340		6	252					6	90	752	2,410	1812,32
	1991		10	340		6	252		1	70		6	90	752	2,579	1939,41
	1980		1	34		-	-		-	-		-	-	34	1,225	41,65
	1981		3	102		-	-		1	70		2	30	202	1,311	264,82
	1982		3	102		1	45					1	15	232	1,403	325 50
	1983		5	170		3	135					5	75	450	1 501	675 45
	1984		7	238		3	135					5	75	518	1 606	831,91
A-3 (A2 FOR SP)	1985	34	10	340	42	6	270	70			15	5	75	755	1 718	1297,09
	1986		10	340		6	270					5	75	755	1 838	1387,69
	1987		10	340		6	270					5	75	755	1 °67	1485,09
	1988		10	340		6	270					5	75	755	2,105	1589,28
	1989		10	340		6	270					5	75	755	2,252	1700,26
	1990		10	340		6	270					6	90	740	2,410	1855,70
	1991		10	340		6	270		1	70		6	90	770	2 579	1985 83
	1980		1	14		-	-		-	-		-	-	14	1,225	17,15
	1981		3	42		-	-		1	17		2	30	89	1 311	116,68
	1982		3	42		1	22					1	15	96	1 403	134 69
	1983		5	70		3	66					5	75	228	1 501	342 23
	1984		7	98		3	66					5	75	256	1 606	411,14
B-1	1985	14	10	140	22	6	132	17			15	5	75	364	1 718	625,35
	1986		10	140		6	132					5	75	364	1,838	669,03
	1987		10	140		6	132					5	75	364	1 967	715,99
	1988		10	140		6	132					5	75	364	2 105	766,22
	1989		10	140		6	132					5	75	364	2 252	819,73
	1990		10	140		6	132					6	90	379	2,410	913 39
	1991		10	140		6	132		1	17		6	90	379	2 579	977,44
	1980		1	14		-	-		-	-		-	-	14	1 225	17,15
	1981		3	42		-	-		1	17		2	30	89	1 311	116 68
	1982		3	42		1	22					1	15	96	1 403	134,69
	1983		5	70		3	66					5	75	228	1 501	342,23
	1984		7	98		3	66					5	75	256	1 606	411,14
B-4	1985	14	10	140	22	6	132	17			15	5	75	364	1 718	625,35
	1986		10	140		6	132					5	75	364	1,838	669,03
	1987		10	140		6	132					5	75	364	1 967	715,99
	1988		10	140		6	132					5	75	364	2 105	766,22
	1989		10	140		6	132					5	75	364	2 252	819,73
	1990		10	140		6	132					6	90	379	2 410	913,39
	1991		10	140		6	132		1	17		6	90	379	2 579	977,44
	1980		1	3		-	-		-	-		-	-	3	1 225	3,68
	1981		3	9		-	-		1	3		2	8	20	1,31ı	26,22
	1982		3	9		1	3					1	4	19	1 403	26 66
	1983		5	15		3	9					5	20	47	1 501	70,55
	1984		7	21		3	9					5	20	53	1 606	85 12
C-1	1985	3	10	30	3	6	18	3			4	5	20	71	1 718	121,98
	1986		10	30		6	18					5	20	71	1 838	130 50
	1987		10	30		6	18					5	20	71	1 967	139,66
	1988		10	30		6	18					5	20	71	2 105	149 46
	1989		10	30		6	18					5	20	71	2 252	159 89
	1990		10	30		6	18					6	24	75	2 410	180 75
	1991		10	30		6	18		1	3		6	24	75	2,579	193 43
	1980		1	3		-	-		-	-		-	-	3	1,225	3,68
	1981		3	9		-	-		1	3		2	8	20	1,311	26 22
	1982		3	9		1	3					1	4	19	1,403	26 66
	1983		5	15		3	9					5	20	47	1 501	70 55
	1984		7	21		3	9					5	20	53	1,606	85,12
C-4	1985	3	10	30	3	6	18	3			4	5	20	71	1 718	121,98
	1986		10	30		6	18					5	20	71	1 838	130,50
	1987		10	30		6	18					5	20	71	1 967	139,66
	1988		10	30		6	18					5	20	71	2 105	149,46
	1989		10	30		6	18					5	20	71	2,252	159,89
	1990		10	30		6	18					6	24	75	2,410	180,75
	1991		10	30		6	18		1	3		6	24	75	2 579	193,43

RESOURCE COST SUMMARY (2/3 BASELINE TRAFFIC MODEL)

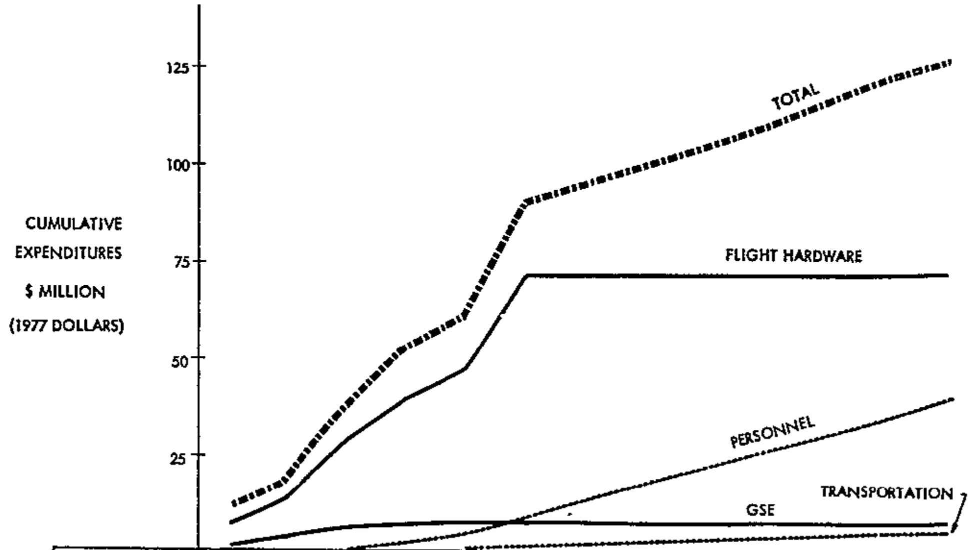
This section summarizes the resource costs for all six options evaluated with the 2/3 Baseline Traffic Model. The previous six subsections defined the options that were evaluated (A-1, A-3, B-1, B-4, C-1 and C-4) and they defined the traffic model (199 Spacelab flights) including the derivation and listings of the launch dates for all options.

The summary of the annual spending profile for option A-1 is demonstrated on Figure 4-1 with the cumulative spending curve being displayed as Figure 4-2. The total funding requirement for this option is $229.46\bar{M}$ (1977$) with the peak funding year occurring in 1984, the year in which the second Core Module is required to support the increase in the traffic model. In 1984, the number of habitable module flights increases from six (1-LS and 5-ATL) to eight (1-LS and 7-ATL). At the current assessed KSC ground processing flow times a Core Module can only support 6 launches per year (if they are spaced at least 42 days apart). This increase in ATL type missions also increased the need for pallet segments and racks in the Spacelab Flight hardware program inventory. This equipment and some additional EPDB's have required an additional $42.84\bar{M}$ in the 1983 funding requirements (costs allocated in the year preceding first use of the equipment) for all options of the 2/3 Baseline Traffic model.



RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	6 28	16 98	10.30	7.12	24.81	--	--	--	--	--	--	--	73 33
PERSONNEL	-	0.22	1 17	1.22	2.60	3.05	4.29	4.29	4.29	4.29	4.29	4.43	4.43	38.57
GSE	1.64	3 26	2 42	--	0.63	--	--	--	--	--	--	--	--	7 95
TRANSPORT'N.	-	0 03	0 20	0 23	0.44	0.51	0 74	0.74	0.74	0 74	0.74	0 75	0.75	6 61
TOTALS '77 $	9.48	9.79	20 77	11.75	10.79	28.37	5 03	5 03	5.03	5 03	5.03	5 18	5 18	126 46
ESCALATED $	11.84	12.38	30.04	18.90	18 74	54.97	11.40	10 67	11 42	12 21	13 07	14 37	15 38	235.39

Figure 4-1 . Option A-1 Resource Summary (Annual Spending) (2/3 Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	14 12	31.09	41.39	48.51	73.33	73.33	73.33	73.33	73 33	73 33	73 33	73 33
PERSONNEL	–	0 22	1 39	2.61	5 21	8.26	12 55	16 84	21.13	25 42	29 71	34 14	38 57
GSE	1 64	4 90	7 32	7.32	7.95	7.95	7 95	7.95	7.95	7.95	7.95	7 95	7 95
TRANSPORT'N	-	0.03	0 23	0.46	0 90	1.41	2 15	2.89	3 63	4 37	5.11	5.86	6.61
TOTALS '77 $	9.48	19 27	40 03	51 78	62 57	90 95	95 98	101.01	106.04	111 07	116 10	121.28	126.46

Figure 4-2 . Option A-1 Cum Spending (2/3 Traffic Model)

The next ten figures are the annual spending charts and the cumulative spending curves for the other five options of the 2/3 Baseline Traffic Model.

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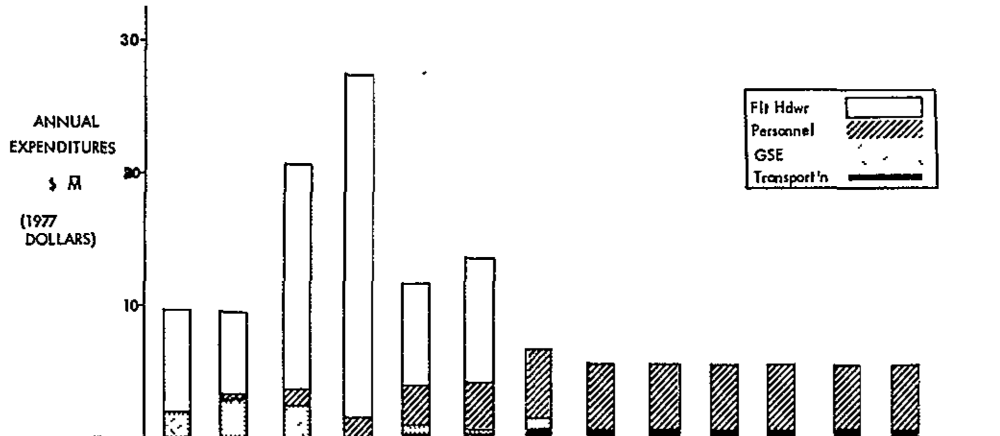
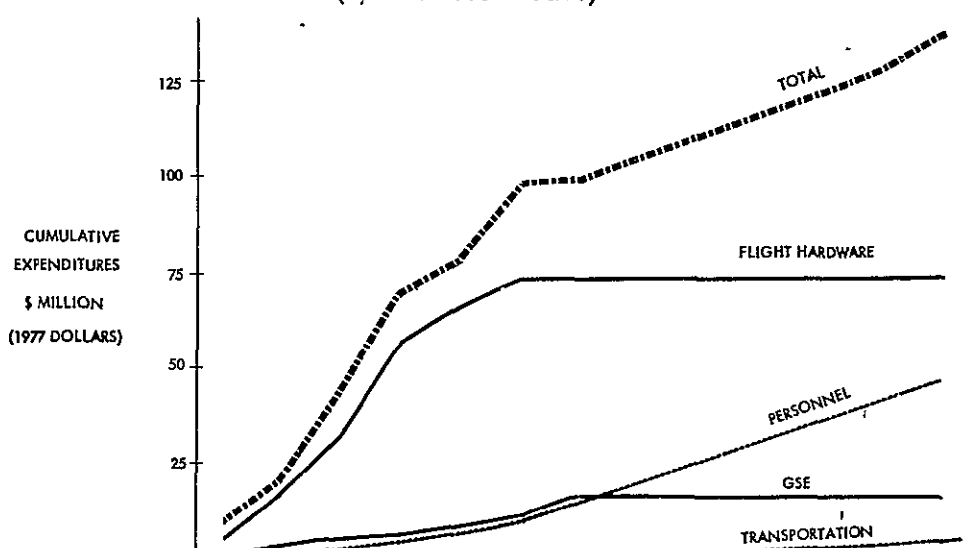


RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7 84	6.28	16.98	25 85	7.84	9 26	--	--	--	--	--	--	--	74 05
PERSONNEL	--	0 27	1.33	1.42	3.00	3 54	5.05	5 05	5 05	5 05	5 05	5 19	5 19	45 19
GSE	2.05	2.98	2 42	--	0.63	0.07	0.83	--	--	--	--	--	--	8 98
TRANSPORT'N.	--	0 03	0 20	0.23	0 45	0.52	0 76	0 76	0 76	0.76	0 76	0 77	0.77	6.77
TOTALS '77 $	9.89	9 56	20.93	27.50	11.92	13 39	6 64	5 81	5 81	5 81	5.81	5 96	5 96	134.99
ESCALATED $	11.84	12 38	30.04	43 95	20 01	24.68	11 40	10.67	11 42	12 21	13 07	14 37	15 38	231 42

Figure 4-3 . Option A-3 Resource Summary (Annual Spending) (2/3 Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	14 12	31.10	56 95	64.79	74 05	74.05	74.05	74 05	74.05	74 05	74 05	74 05
PERSONNEL	-	0 27	1 60	3 02	6.02	9 54	14.61	19.66	24.71	29 76	34 81	40 00	45.19
GSE	2 05	5.03	7 45	7.45	8 08	8.15	8.98	8.98	8.98	8 98	8 98	8.98	8.98
TRANSPORT'N.		0 03	0 23	0.46	0 91	1.43	2.19	2 95	3.71	4 47	5 23	6.00	6 77
TOTALS '77 $	9.89	19.45	40.37	67.87	79.79	93 17	99.83	105 64	111.45	117 26	123.07	129.03	134.99

Figure 4-4 . Option A-3 Cum Spending 2/3 Baseline Traffic Model

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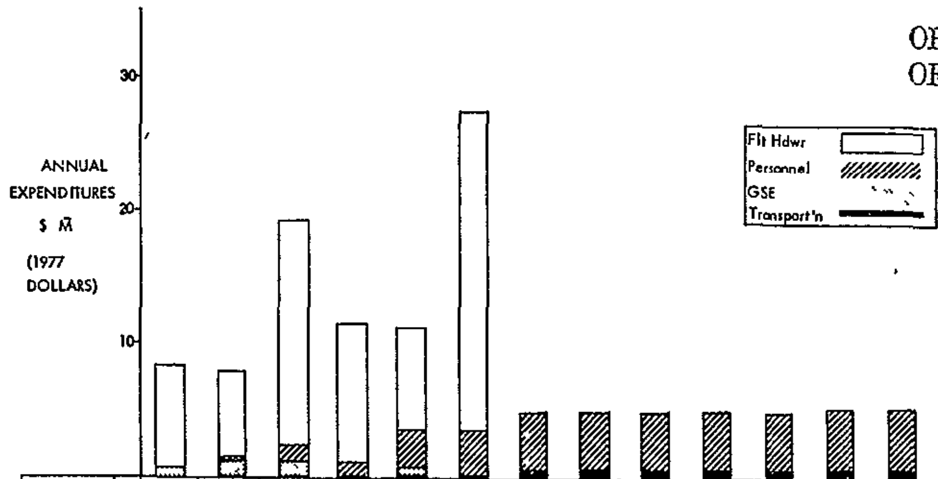
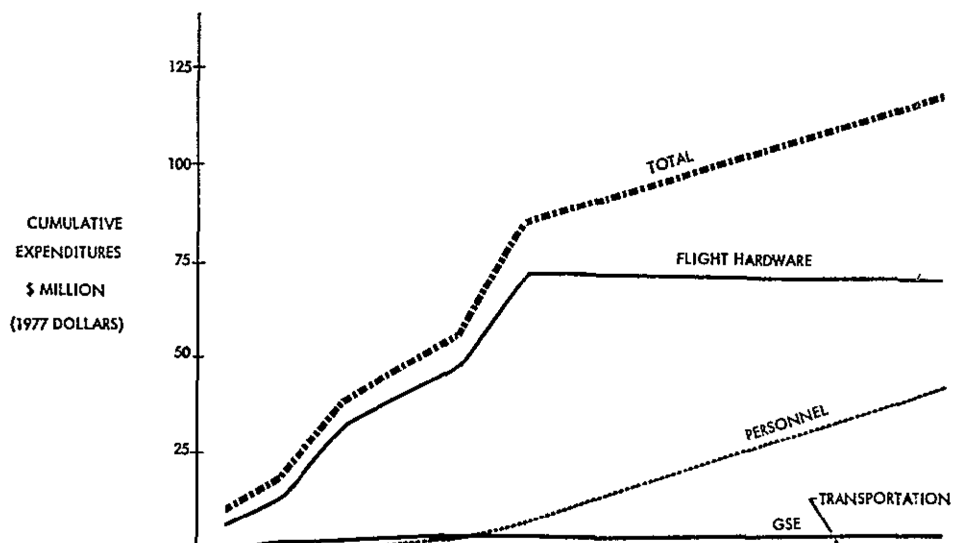


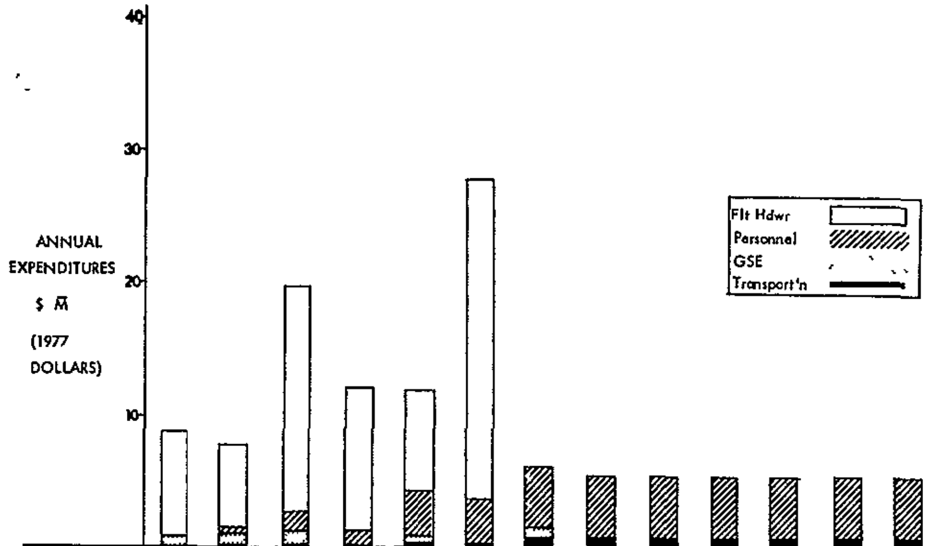
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7,84	6 28	16,97	10,30	7,84	24,10	--	--	- -	--	--	--	--	73 33
PERSONNEL	--	0,24	1 22	1 27	2 76	3 23	4 55	4 55	4 55	4 55	4 55	4,70	4 70	40 87
GSE	0,83	1,32	1 25	--	0 39	--	--	--	--	--	--	--	--	3 79
TRANSPORT'N.	--	0,01	0,09	0,10	0,23	0,26	0,36	0,36	0,36	0,36	0,36	0,38	0,38	3,25
TOTALS '77 $	8,67	7 85	19,53	11,67	11 22	27,59	4 91	4 91	4 91	4 91	4 91	5 08	5 08	121,24
ESCALATED $	10.44	10.28	28.20	18,51	18,96	52.56	8.44	9.03	9 66	10 34	11 06	12 23	13 10	212,82

Figure 4-5 . Option B-1 Resource Summary (Annual Spending)
(2/3 Traffic Model)



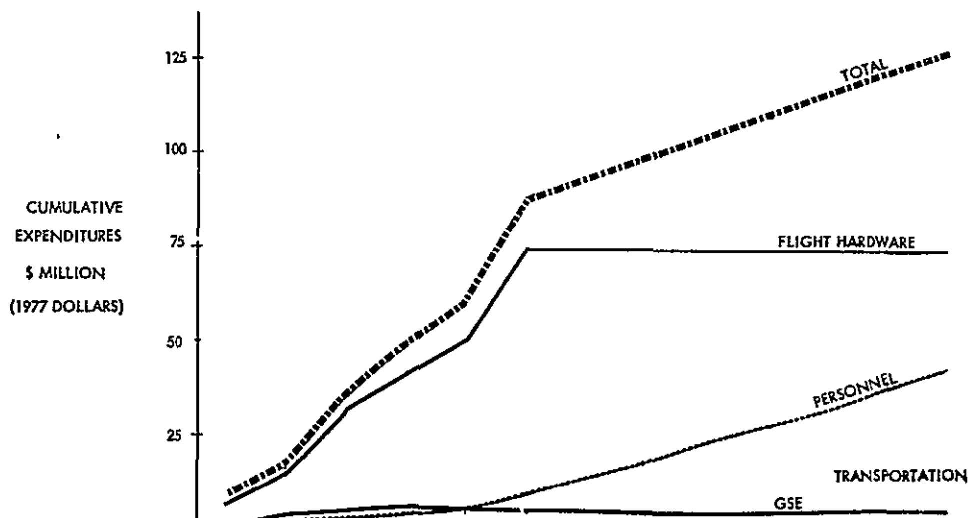
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7,84	14 12	31 09	41,39	49 23	73,33	73.33	73 33	73,33	73 33	73 33	73 33	73 33
PERSONNEL	-	0,24	1 46	2 73	5,49	8,72	13,27	17 82	22 37	26,92	31 47	36 17	40 87
GSE	0,83	2 15	3 40	3 40	3,79	3,79	3 79	3 79	3 79	3,79	3 79	3,79	3 79
TRANSPORT'N.	-	0 01	0 10	0,20	0,43	0 69	1,05	1 41	1.77	2,13	2,49	2,87	3,25
TOTALS '77 $	8,67	16.52	36,05	47,72	58,94	86,53	91 44	96,35	101,26	106,17	111,08	116,16	121,24

Figure 4-6 . Option B-1 Cum Spending (2/3 Baseline Traffic Model)



RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.80	6.28	16 97	10.30	7.84	24.10	--	--	--	--	--	--	--	73.33
PERSONNEL	—	0 25	1.26	1 31	2 85	3 35	4 73	4 73	4.73	4 73	4 73	4 89	4 89	42 45
GSE	0 79	1 18	1 21	--	0.35	--	0.78	--	--	--	0.44	--	--	4.75
TRANSPORT'N.	—	0 01	0 09	0 10	0 23	0 26	0 36	0 36	0 36	0.36	0 36	0 38	0 38	3 25
TOTALS '77 $	8.59	7.72	19.53	11.71	11.27	27 71	5 87	5 09	5 09	5 09	5 53	5 27	5 27	123.78
ESCALATED $	10.34	10.12	28 20	18.57	19.04	52 75	10 09	9 35	10 01	10.72	11 46	12 67	13 57	216 89

Figure 4-7 . Option B-4 Resource Summary (Annual Spending) (2/3 Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	14 12	31.09	41.39	49 23	73.33	73.33	73.33	73.33	73.33	73 33	73 33	73.33
PERSONNEL	-	0.25	1 51	2 82	5 67	9.02	13.75	18.48	23.21	27.94	32.67	37 56	42 45
GSE	0.79	1.97	3.18	3.18	3.53	3 53	4 31	4 31	4.31	4.31	4.75	4 75	4 75
TRANSPORT'N.	-	0.01	0.10	0 20	0 43	0 69	1.05	1.41	1.77	2.13	2 49	2 87	3 25
TOTALS '77 $	8.63	16 35	35.88	47.59	58 86	86 57	92 44	97 53	102 62	107.71	113 24	118.51	123.78

Figure 4-8 . Option B-4 Cum Spending 2/3 Baseline Traffic Model

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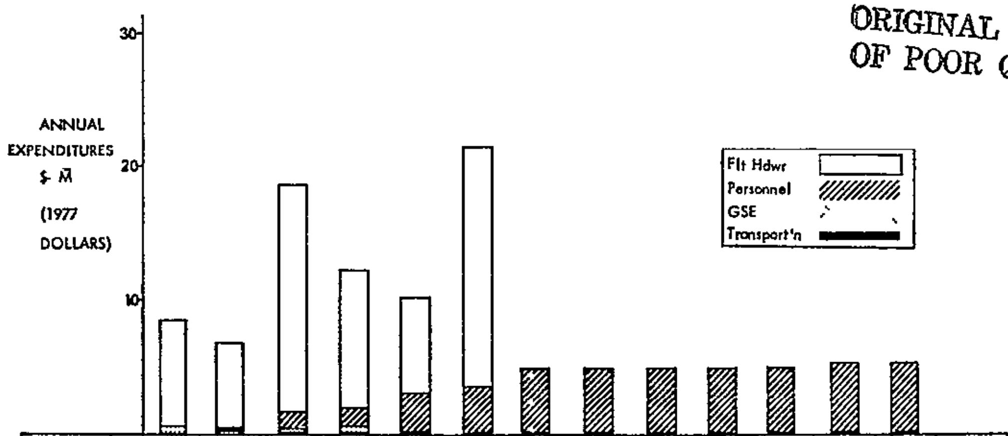
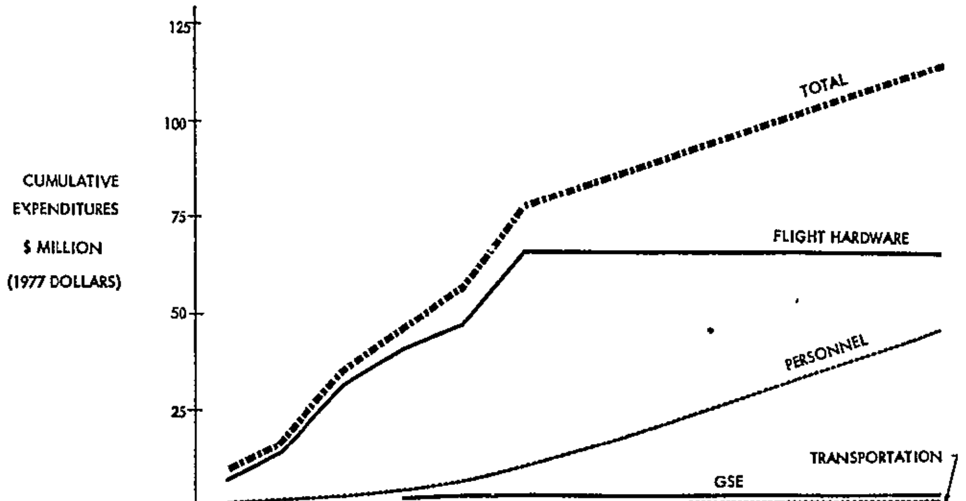


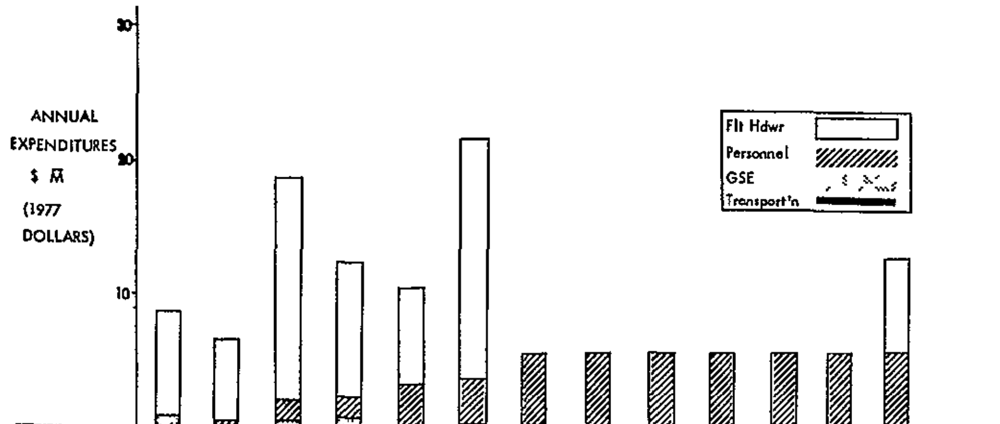
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	6 28	16.97	10.30	7.12	17.69	--	--	—	--	--	—	--	66.20
PERSONNEL	—	0.26	1 36	1.43	3 14	3 66	5 19	5 19	5.19	5 19	5 19	5 36	5 36	46 52
GSE	0 83	0 25	0 51	0 60	--	--	--	--	--	--	--	--	--	2 19
TRANSPORT'N.	—	—	0.02	0 02	0 05	0 05	0 07	0 07	0.07	0 07	0 07	0 08	0 08	0 65
TOTALS '77 $	8 67	6 79	18.86	12 35	10 31	21 40	5 26	5 26	5 26	5 26	5 26	5 44	5 44	115.56
ESCALATED $	10 44	8.98	27.32	19.47	17.41	34 37	9.03	9 66	10.34	11 06	11 84	13 09	14 01	197.02

Figure 4-9 . Option C-1 Resource Summary (Annual Spending) (2/3 Traffic Model)



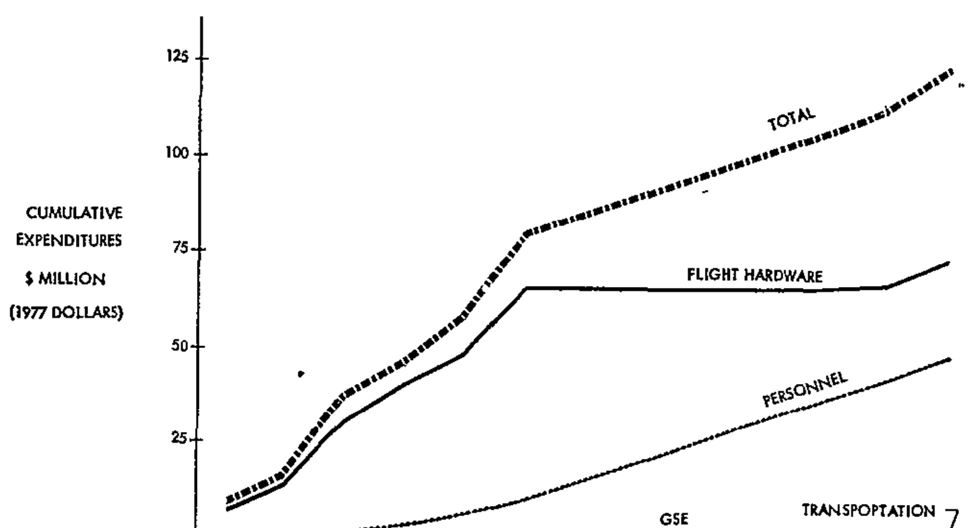
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	14.12	31.09	41 39	48.51	66.21	66.21	66.21	66.21	66 21	66.21	66 21	66 21
PERSONNEL	-	0 26	1.62	3.05	6 19	9.85	15 04	20.23	25.42	30 61	35.80	41.16	46 52
GSE	0.83	1.08	1.59	2 19	2.19	2.19	2.19	2.19	2 19	2 19	2.19	2.19	2.19
TRANSPORT'N.	-	-	0.02	0 04	0.09	0.14	0 21	0 28	0 35	0.42	0 49	0.57	0 65
TOTALS '77 $	8 67	15.46	34 32	46 67	56'98	78 39	83 65	88 91	94 17	99 43	104 69	110.13	115.57

Figure 4-10 . Option C-1 Cum Spending 2/3 Baseline Traffic Model



RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	6.28	16.97	10.30	7.12	17 69	--	--	--	--	--	--	7 13	73 33
PERSONNEL	--	0.29	1 44	1.49	3.25	3 82	5 38	5 38	5 38	5 38	5.38	5 56	5 56	48 31
GSE	0 79	0 11	0 54	0 59	--	--	--	--	--	--	--	--	—	2.03
TRANSPORT'N	--	—	0 02	0 02	0 05	0 05	0 07	0 07	0 07	0'07	0 07	0 08	0 08	0.65
TOTALS '77 $	8.63	6 68	18.97	12.40	10.42	21 56	5.45	5 45	5 45	5 45	5 45	5 64	12 77	124.32
ESCALATED $	10 39	8 85	27.46	19.54	17 57	34 63	9 36	10.02	10.72	11 47	12 28	13 57	41.58	227 44

Figure 4-11. Option C-4 Resource Summary (Annual Spending) (2/3 Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	14.12	31.09	41 39	48 51	66.20	66 20	66.20	66 20	66.20	66 20	66.20	73 33
PERSONNEL	-	0 29	1.73	3 22	6.47	10 29	15 67	21 05	26 43	31.81	37.19	42 75	48 31
GSE	0 79	0 90	1.44	2 03	2.03	2 03	2 03	2 03	2 03	2.03	2 03	2 03	2 03
TRANSPORT'N.	-	-	0.02	0 04	0.09	0 14	0 21	0 28	0 35	0 42	0 49	0 57	0.65
TOTALS '77 $	8 63	15.31	34 28	46.68	57 10	79.66	84.11	89 56	95.01	100.46	105.91	111 55	124 31

Figure 4-12. Option C-4 Cum Spending 2/3 Baseline Traffic Model

Table 4-47 contains a summary of the total resource requirements for all six options evaluated for the 2/3 Baseline Traffic Model. Option C-1 has the lowest total program costs at $218.56\overline{M}$ (1977 $). Option C-1 has the lowest total ground processing Level IV integration costs because in three of the four categories it had the lowest costs of the six options evaluated. In the area of Spacelab flight hardware costs, this option and C-4 required the least amount of Spacelab flight hardware ($7\overline{M}$ less than the second closest option). Option C-1 and B-1 also required the least amount of GSE ($2.19\overline{M}$) and it had the lowest transportation costs (also the same amount for C-4). The lower cost requirements in these three areas offset the fact that options C-1 and C-4 had the highest personnel costs of all six options.

Table 4-47 . Summary of Option Costs (1977 $ M) - 2/3 Baseline Traffic Model

RESOURCE	OPTION					
	A-1	A-3	B-1	B-4	C-1	C-4
FLIGHT HARDWARE	73.33	74.05	73.33	73.33	66.20	73.33
PERSONNEL	38.57	45.19	40.87	42.45	46.52	48.31
GSE	7.95	8.98	3.79	4.75	2.19	2.03
TRANSPORTATION	6.61	6.77	3.25	3.25	0.65	0.65
TOTALS	126.46	134.99	121.24	123.78	115.56	124.32

The differences in total costs between all six options are shown below:

		Delta $ M	% Delta
C-1	115.56	0	0
B-1	121.24	5.68	4.9
B-4	123.78	8.22	6.2
C-4	124.32	8.76	7.6
A-1	126.46	10.90	9.4
A-3	134.99	19.43	16.8

5.0 LEVEL IV GROUND PROCESSING REQUIREMENTS - 1/3 TRAFFIC MODEL

5.0 LEVEL IV GROUND PROCESSING REQUIREMENTS

1/3 TRAFFIC MODEL

SCOPE OF PROGRAMMATIC ANALYSIS

This section describes the programmatic analyses performed during the study based on the 1/3 Traffic Model. The same site options were considered for analyses as described in section 3.0 of this volume. The same basic guidelines itemized in an earlier section were also applied here.

The 1/3 Traffic Model is a derivative of the "560" traffic model based on the study (equivalency) model using the four selected payloads. Buildup analyses based on ground processing times were performed and included along with a schedule analyses reflecting the development of payload launch dates.

Spectrum of Options

A detailed description of the options applicable to the analyses based on a 1/3 traffic model is found in section 3.0 of this volume. The options considered for the 1/3 model were: (1) Distributed Site, (2) Lead Center, and (3) KSC. The same 6 buildup options were also used in the Programmatic Evaluation using similar criteria found in section 3.0 "Options Selected for Programmatic Evaluation". Table 3-3 lists these options.

Programmatic Guidelines

The concept behind the "Programmatic Guidelines" found in section 3.0 of this volume is applicable; however, these guidelines were adjusted as required by the reduction in the payload quantity to 1/3 of the baseline traffic model.

TRAFFIC MODEL ANALYSIS

Payload Equivalencies

Payload equivalencies were based on the "STS Traffic Model, 1980-1991" as described in Section 3.0 of this volume biased by a reduction in missions of a factor approximating 1/3.

Prior to applying the 1/3 factor an equivalencie traffic model was produced relating the four study payloads to the basic model. The equivalencie model is shown in Table 3-5. Table 5-1 identifies the 1/3 traffic model used.

Table 5-1. Traffic Model for Programmatic Analyses

Year		80	81	82	83	84	85	86	87	88	89	90	91	Totals
1/3	LS	-	1	-	1	-	1	-	1	-	1	-	1	6
	ATL	1	1	1	3	4	4	5	4	5	5	5	5	43
	CA	-	-	1	1	2	3	3	3	3	3	3	3	25
	SP	-	1	1	2	2	3	3	3	3	2	3	2	25
	Total	1	3	3	7	8	11	11	11	11	11	11	11	99

Buildup Analysis

The Spacelab Ground Processing times developed for the baseline traffic model were applied to the 1/3 traffic model. Similarly to the baseline buildup analysis, the NASA provided 80 percent learning curve would be applicable.

The study groundrule used in the buildup analysis was that the learning curve would be used for either the first five flights or two years of operations, whichever comes first. For example, in the 1/3 Traffic Model in the distributed and lead center options, those centers associated with the Life Science payloads do not become "operational" (achieve steady-state processing times) until 1983 (third year of operations), the ATL centers are operational in 1981 (second year of operations), the Combined Astronomy and Space Processing centers in 1983 (also second year of operations). In the case of the KSC options, this Level IV processing site would be a steady-state level in the 1981-82 time frame because the launch site, at that time, would be in its second year of operations and be processing its fifth flight.

Schedule Analysis

A schedule analysis similar to that performed on the baseline traffic model was performed to derive the 1/3 mission model. The only difference being that the quantity of flights were reduced. The same groundrules and guidelines were used in the 1/3 schedule analysis as were used in the baseline model. A detailed description is found in Section 3.0 entitled "Schedule Analysis".

Table 5-2. 1/3 Traffic Model

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1980	1	130		x		
			-	1	-	-
1981	1	87		x		
	2	173				x
	3	260	x			
			1	1	-	1
1982	1	87			x	
	2	173		x		
	3	260				x
			-	1	1	1
1983	1	37		x		
	2	74				x
	3	111	x			
	4	149			x	
	5	186		x		
	6	223				x
	7	260		x		
			1	3	1	2
1984	1	33			x	
	2	65		x		
	3	98				x
	4	130		x		
	5	163			x	
	6	195		x		
	7	228				x
	8	260		x		
			-	4	2	2
1985 1987	1	24			x	
	2	48		x		
	3	71				x
	4	95		x		
	5	119			x	
	6	142	x			
	7	166				x
	8	189		x		
	9	213			x	
	10	236		x		
	11	260				x
			1	4	3	3
1986 1988	1	24			x	
	2	48		x		

Table 5-2. 1/3 Traffic Model

YEAR	FLIGHT	DAY	PAYLOAD			
			LS	ATL	CA	SP
1990	3	71				x
	4	95		x		
	5	119			x	
	6	142		x		
	7	166				x
	8	189		x		
	9	213			x	
	10	236		x		
	11	260				x
			-	5	3	3
1989 1991	1	24		x		
	2	48			x	
	3	71		x		
	4	95				x
	5	119		x		
	6	142			x	
	7	166	x			
	8	189				x
	9	213		x		
	10	236			x	
	11	260		x		
			1	5	3	2

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PERSONNEL REQUIREMENTS - 1/3 TRAFFIC MODEL

The manpower and TDY requirements developed for each payload on a per mission basis were described in the "Manpower Baseline" and "Personnel Cost Analyses Tables" in section 3.0 of this volume. These data are applicable in this section as well, including Tables 3-9 through 3-12.

In applying the 1/3 Traffic Model to this data, the same approach was followed as with the Baseline and 2/3 Traffic Models. The total pre-flight costs for each payload were multiplied by the number of flights for that payload in the given year, to give the total cost for the year for each payload. These were then totaled for the four payloads to yield the annual grand total costs for personnel, both manpower and TDY. Payload totals are also shown for reference. This data is presented in Tables 5-3 through 5-8 for Options A-1, A-3, B-1, B-4, C-1, and C-4 respectively.

As with the 2/3 Traffic Model data, the annual spending largely stabilizes after the first four or five years, due to the nearly constant flight rate of the payloads. Annual personnel costs are strictly a function of the flight rate. This trend is more evident in the annual and cumulative cost charts in the section entitled, "Resource Cost Summary (1/3 Baseline Traffic Model)."

In order to compare the "Hands-on" Level IV integration manpower costs, it is necessary to first compare the costs between like options (Option A-1 to B-1 to C-1). The second part will be an evaluation among cases of the same option group (A-1 to A-3, B-1 to B-4, C-1 to C-4). In general, the total payload manpower costs will increase from the distributed options (A-1, 19.14 $\bar{M}$\$) to the Lead Center options (B-1, 20.53 $\bar{M}$\$) and the highest being the KSC options (C-1, 23.08 $\bar{M}$\$). This difference is attributable to two factors: TDY and Host-Center Support. Of the four major elements of the Level IV personnel costs:

Level IV Integration "Hands-On" personnel
KSC Operations Support
TDY Costs
Host-Center Support

the first two elements remain almost constant from one option to another. The technicians and engineers required to physically install and checkout the Drop Dynamics experiment in its double rack will be the same if this effort is done by the Principal Investigator (PI) and his staff at the Jet Propulsion Lab (JPL) in Pasadena (an example of a Distributed Center), or at MSFC (Lead Center), or at KSC. Also, the KSC Operations Support category which is the PI's and one or two key personnel that they may require on site at KSC during the STS Operations (functional blocks 10 thru 15 of this study) will be the same for all options since the KSC Operations Support requirements are independent of the Level IV integration site. Therefore, the factors that would vary between options are the TDY and Host Center Support requirements. These two elements vary according to the Level IV Integration site being considered and also according to the payload being evaluated. At the distributed sites there was a smaller amount of TDY required because of the nature of selecting the

the distributed sites. They were chosen by the logic groupings of the flight hardware. In the L/S example, 8 mini-centers were selected. This payload had 20 different experiments and, therefore, at most 12 PI's would be traveling. In the actual analysis, there were less than the 12 PI's who were required to travel to a mini-center. In the centralized options, there were more required to more because there was only one LS centralized site. But it was assumed that site selected as Lead Center would be done so because they were sponsoring some significant portion of the effort on that particular payload. The average worked out that approximately one-half of the PI's for a given payload would be resident at the Lead Center. In the KSC case, it was assumed that all PI's and their staff would be on TDY status during the level IV integration activities at KSC. The Host Center support estimates were made utilizing the same rationale. Namely, that progressively at each site, from Distributed to Lead Center to KSC, there would be increasing requirements for the Host site to provide some effort in support of the PI's and their staffs that were traveling to that site, and as such were relatively unfamiliar with the procedures and the location. The comparison between options will show that the -3 and -4 options always have higher personnel costs than their corresponding -1 options: A-3 (22.4 $\bar{M}$\$) compared to A-1 (19.1 $\bar{M}$\$), B-4 (21.0 $\bar{M}$\$) and B-1 (20.5 $\bar{M}$\$), and C-4 (23.9 $\bar{M}$\$) to C-1 (23.1 $\bar{M}$\$). This results from the additional integration activities associated with the combined payload checkout (functional blocks 7, 8, 9).

OPTION A-1

TABLE 5-3. 1/3 TRAFFIC MODEL
(1977 K$ - MANPOWER COSTS)

YEAR	ATL FLTS	ATL M/P	ATL TDY	LIFE SCIENCE FLTS	LIFE SCIENCE M/P	LIFE SCIENCE TDY	COMB ASTRON. FLTS	COMB ASTRON. M/P	COMB ASTRON. TDY	SPACE PROC. FLTS	SPACE PROC. M/P	SPACE PROC. TDY	M/P	TDY
1980	1	194	31	-	-	-	-	-	-	-	-	-	194	31
81	1	194	31	1	193	22	-	-	-	1	119	21	506	74
82	1	194	31	-	-	-	1	167	20	1	119	21	480	72
83	3	582	93	1	193	22	1	167	20	2	238	42	1,180	177
84	4	776	124	-	-	-	2	334	40	2	238	42	1,348	206
85	4	776	124	1	193	22	3	501	60	3	357	63	1,827	269
86	5	970	155	-	-	-	3	501	60	3	357	63	1,828	278
87	4	776	124	1	193	22	3	501	60	3	357	63	1,827	269
88	5	970	155	-	-	-	3	501	60	3	357	63	1,828	278
89	5	970	155	1	193	22	3	501	60	2	238	42	1,902	279
90	5	970	155	-	-	-	3	501	60	3	357	63	1,828	278
91	5	970	155	1	193	22	3	501	60	2	238	42	1,902	279
TOTALS	43	8,342	1,333	6	1,158	132	25	4,175	500	25	2,975	525	16,650	2,490

OPTION A-3

TABLE 5-4. 1/3 TRAFFIC MODEL
(1977 K$ - MANPOWER COSTS)

YEAR	ATL FLTS	ATL M/P	ATL TDY	LIFE SCIENCE FLTS	LIFE SCIENCE M/P	LIFE SCIENCE TDY	COMB ASTRON. FLTS	COMB ASTRON. M/P	COMB ASTRON. TDY	SPACE PROC. FLTS	SPACE PROC. M/P	SPACE PROC. TDY	M/P	TDY
1980	1	224	41	-	-	-	-	-	-	-	-	-	224	41
81	1	224	41	1	212	31	-	-	-	1	123	21	559	93
82	1	224	41	-	-	-	1	207	32	1	123	21	554	94
83	3	672	123	1	212	31	1	207	32	2	246	42	1,337	228
84	4	896	164	-	-	-	2	414	64	2	246	42	1,556	270
85	4	896	164	1	212	31	3	621	96	3	369	63	2,098	354
86	5	1,120	205	-	-	-	3	621	96	3	369	63	2,110	364
87	4	896	164	1	212	31	3	621	96	3	369	63	2,098	354
88	5	1,120	205	-	-	-	3	621	96	3	369	63	2,110	364
89	5	1,120	205	1	212	31	3	621	96	2	246	42	2,199	374
90	5	1,120	205	-	-	-	3	621	96	3	369	63	2,110	364
91	5	1,120	205	1	212	31	3	621	96	2	246	42	2,199	374
TOTALS	43	9,632	1,763	6	1,272	186	25	5,175	800	25	3,075	525	19,154	3,274

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OPTION B-1

TABLE 5-5. 1/3 TRAFFIC MODEL
(1977 K$ - MANPOWER COSTS)

	ATL			LIFE SCIENCE			COMB ASTRON.			SPACE PROC.				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	200	39	-	-	-	-	-	-	-	-	-	200	39
81	1	200	39	1	163	34	-	-	-	1	124	28	487	101
82	1	200	39	-	-	-	1	174	26	1	124	28	498	93
83	3	600	117	1	163	34	1	174	26	2	248	56	1,185	233
84	4	800	156	-	-	-	2	348	52	2	248	56	1,396	264
85	4	800	156	1	163	34	3	522	78	3	372	84	1,857	352
86	5	1,000	195	-	-	-	3	522	78	3	372	84	1,894	357
87	4	800	156	1	163	34	3	522	78	3	372	84	1,857	352
88	5	1,000	195	-	-	-	3	522	78	3	372	84	1,894	357
89	5	1,000	195	1	163	34	3	522	78	2	248	56	1,933	363
90	5	1,000	195	-	-	-	3	522	78	3	372	84	1,894	357
91	5	1,000	195	1	163	34	3	522	78	2	248	56	1,933	363
TOTALS	43	8,600	1,677	6	978	204	25	4,350	650	25	3,100	700	17,028	3,231

OPTION B-4

TABLE 5-6. 1/3 TRAFFIC MODEL
(1977 K$ - MANPOWER COSTS)

	ATL			LIFE SCIENCE			COMB ASTRON.			SPACE PROC.				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	202	49	-	-	-	-	-	-	-	-	-	202	49
81	1	202	49	1	158	35	-	-	-	1	128	28	488	112
82	1	202	49	-	-	-	1	170	37	1	128	28	500	114
83	3	606	147	1	158	35	1	170	37	2	256	56	1,190	275
84	4	808	196	-	-	-	2	340	74	2	256	56	1,404	326
85	4	808	196	1	158	35	3	510	111	3	384	84	1,860	426
86	5	1,010	245	-	-	-	3	510	111	3	384	84	1,904	440
87	4	808	196	1	158	35	3	510	111	3	384	84	1,860	426
88	5	1,010	245	-	-	-	3	510	111	3	384	84	1,904	440
89	5	1,010	245	1	158	35	3	510	111	2	256	56	1,934	447
90	5	1,010	245	-	-	-	3	510	111	3	384	84	1,904	440
91	5	1,010	245	1	158	35	3	510	111	2	256	56	1,934	447
TOTALS	43	8,686	2,107	6	948	210	25	4,250	925	25	3,200	700	17,084	3,942

OPTION C-1

TABLE 5-7. 1/3 TRAFFIC MODEL
(1977 K$ - MANPOWER COSTS)

	ATL			LIFE SCIENCE			COMB ASTRON.			SPACE PROC.				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	206	58	-	-	-	-	-	-	-	-	-	206	58
81	1	206	58	1	169	53	-	-	-	1	130	43	505	154
82	1	206	58	-	-	-	1	181	62	1	130	43	517	163
83	3	618	174	1	169	53	1	181	62	2	260	86	1,228	375
84	4	824	232	-	-	-	2	362	124	2	260	86	1,446	442
85	4	824	232	1	169	53	3	543	186	3	390	129	1,926	600
86	5	1,030	290	-	-	-	3	543	186	3	390	129	1,963	605
87	4	824	232	1	169	53	3	543	186	3	390	129	1,926	600
88	5	1,030	290	-	-	-	3	543	186	3	390	129	1,963	605
89	5	1,030	290	1	169	53	3	543	186	2	260	86	2,002	615
90	5	1,030	290	-	-	-	3	543	186	3	390	129	1,963	605
91	5	1,030	290	1	169	53	3	543	186	2	260	86	2,002	615
TOTALS	43	8,858	2,494	6	1,014	318	25	4,525	1,550	25	3,250	1,075	17,647	5,437

OPTION C-4

TABLE 5-8. 1/3 TRAFFIC MODEL
(1977 K$ - MANPOWER COSTS)

	ATL			LIFE SCIENCE			COMB ASTRON.			SPACE PROC.				
YEAR	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	FLTS	M/P	TDY	M/P	TDY
1980	1	209	76	-	-	-	-	-	-	-	-	-	209	76
81	1	209	76	1	168	56	-	-	-	1	134	44	511	176
82	1	209	76	-	-	-	1	176	60	1	134	44	519	180
83	3	627	228	1	168	56	1	176	60	2	268	88	1,239	432
84	4	836	304	-	-	-	2	352	120	2	268	88	1,456	512
85	4	836	304	1	168	56	3	528	180	3	402	132	1,934	672
86	5	1,045	380	-	-	-	3	528	180	3	402	132	1,975	692
87	4	836	304	1	168	56	3	528	180	3	402	132	1,934	672
88	5	1,045	380	-	-	-	3	528	180	3	402	132	1,975	692
89	5	1,045	380	1	168	56	3	528	180	2	268	88	2,009	704
90	5	1,045	380	-	-	-	3	528	180	3	402	132	1,975	692
91	5	1,045	380	1	168	56	3	528	180	2	268	88	2,009	704
TOTALS	43	8,987	3,268	6	1,008	336	25	4,400	1,500	25	3,350	1,100	17,745	6,204

GSE REQUIREMENTS - 1/3 TRAFFIC MODEL

In this section, the GSE quantities and costs associated with the reduced flight rates of the 1/3 traffic model are presented. The composition and per-set cost of the GSE sets associated with each payload and processing option are not changed as a result of the reduced flight rates, because the sets themselves represent the minimum equipment required to process a payload, even if only flown once. Therefore, the GSE sets required for this traffic model were presented in Section "GSE Requirements", as follows:

- Life Science Payload - Tables 3-19 through 3-31
- Combined Astronomy Payload - Tables 3-32 through 3-37
- Space Processing Payload - Tables 3-38 and 3-39
- Advanced Technology Laboratory Payload - Tables 3-40 through 3-45

In order to establish the GSE resource spending requirements for the reduced flight rate associated with the 1/3 Traffic Model, the methodology described above under Programmatic GSE Assessment was applied for the new flight rate, and a new set of year-by-year expenditure charts prepared for each payload and processing option. These are presented herein as Tables 5-9 through 5-14. As in section entitled GSE Requirements, a final summary table also escalating the cost figures for inflation is presented in Table 5-15.

In reviewing this summary data by option, it is evident that GSE costs decrease significantly from the minicenter approach to lead center, and further from lead center to KSC. This is due to increased sharing and utilization of the GSE. In the distributed concept, there is considerable duplication of GSE between minicenters (15 minicenters for the four payloads). This duplication is largely eliminated at the lead centers where a single set for the payload being integrated is used - a maximum of 4 sets of GSE with only partial duplication for common usage items. In the case of KSC integration, this is reduced even further because of sharing one common GSE set between payloads. These cost differentials are due not only to a need for more GSE as integration sites are distributed, but also an increase in transportation costs required to ship GSE from and to the KSC depot in the lead center and distributed cases. This effort is evident when comparing the total GSE costs between A-1, B-1, and C-1, and between B-4 and C-4 options.

The difference between the results of this study with minimum flight rates and the Baseline Traffic Model is again lower expenditures for GSE. Again, the reduction is not proportional to the reduction in flight rate because of the minimum number of sets required. In fact, in this traffic model, only one basic complement of GSE sets was required, and no second sets were required for the entire program period.

TABLE 5-9. ANNUAL GSE EXPENDITURES
(1977 $K)

OPTION A-1 | 1/3 TRAFFIC MODEL

Year	KSC	Life Science								ATL			Comb. Astr.			SP	Totals	
		1	2	3	4	5	6	7	8	1	2	3	1	2	3	1	Direct	+ Spares
1979										585	187.5	592.5					1365	1638
1980		344	364	199	185	185	315	185	424							513.5	2714.5	3257.4
1981													628.5	817	571.5		2017	2420.4
1982																		
1983																		
1984																		
1985																		
1986																		
1987																		
1988																		
1989																		
1990																		
1991																		
Total		344	364	199	185	185	315	185	424	585	187.5	592.5	628.5	817	571.5	513.5	6096.6	7315.8

TABLE 5-10. ANNUAL GSE EXPENDITURES
(1977 $K)

OPTION A-3 | 1/3 TRAFFIC MODEL

Year	KSC	Life Science								ATL			Comb. Astr.			SP	Totals	
		1	2	3	4	5	6	7	8	1	2	3	1	2	3	1	Direct	+ Spares
1979	342.5									585	187.5	592.5					1707.5	2049
1980		344	364	199	185	185	315	185	424							513.5	2714.5	3257.4
1981													628.5	817	571.5		2017	2420.4
1982																		
1983																		
1984																		
1985																		
1986																		
1987																		
1988																		
1989																		
1990																		
1991																		
Totals	342.5	244	364	199	185	185	315	185	424	585	189.5	592.5	628.5	817	571.5	513.5	6439	7726.8

TABLE 5-11. ANNUAL GSE EXPENDITURES
(1977 $K)

OPTION B-1

1/3 TRAFFIC MODEL

Year	Life Science	ATL	Combined Astronomy	Space Processing	Totals	
					Direct	+ Spares
1979		693.5			693.5	832.2
1980	585			513.5	1098.5	1318.2
1981			1042.5		1042.5	1251
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
Totals	585	693.5	1042.5	513.5	2834.5	3401.4

TABLE 5-12. ANNUAL GSE EXPENDITURES
(1977 $K)

OPTION B-4

1/3 TRAFFIC MODEL

Year	Life Science	ATL	Combined Astronomy	Space Processing	Totals	
					Direct	+ Spares
1979		658.5			658.5	790.2
1980	470.5			513.5	984	1180.8
1981			1009.5		1009.5	1211.4
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
Totals	470.5	658.5	1009.5	513.5	2652	3182.4

TABLE 5-13. ANNUAL GSE EXPENDITURES
(1977 $K)

OPTION C-1 COMBINED KSC GSE SET 1/3 TRAFFIC MODEL

Year	Processing GSE	Transportation GSE	Total Direct	Total With Spares
1979	369.0	324.5	693.5	832.0
1980	76.0	135.5	211.5	254.0
1981	51.0	369.5	420.5	505.0
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
Total	496.0	829.5	1325.5	1591.0

TABLE 5-14. ANNUAL GSE EXPENDITURES
(1977 $K)

OPTION C-4 COMBINED KSC GSE SET 1/3 TRAFFIC MODEL

Year	Processing GSE	Transportation GSE	Total Direct	Total With Spares
1979	369.0	289.5	658.5	790.0
1980	76.0	14.5	90.5	109.0
1981	50.0	401.0	451.0	541.0
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
Total	495.0	705.0	1200.0	1440.0

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TABLE 5-15. GSE COST SUMMARY, 1/3 TRAFFIC MODEL

		79	80	81	82	83	84	85	86	87	88	89	90	91	Totals
1977 Dollars	A-1	1638	3258	2420											7316
	A-3	2049	3258	2420											7727
	B-1	832	1318	1251											3401
	B-4	790	1181	1211											3182
	C-1	832	254	505											1591
	C-4	790	109	541											1440
Escalated Dollars	A-1	1876	3991	3173											9040
	A-3	2346	3991	3173											9510
	B-1	953	1615	1640											4208
	B-4	905	1447	1588											3940
	C-1	953	311	662											1926
	C-4	905	134	709											1748

SPACELAB FLIGHT HARDWARE REQUIREMENTS (1/3 BASELINE TRAFFIC MODEL)

Spacelab Flight Hardware Elements Evaluated

In the analyses and evaluations conducted for the 1/3 Baseline traffic model, the same Spacelab Flight hardware end items were reviewed as in the baseline and 2/3 baseline traffic models. The end items and their costs in millions of 1977 dollars are shown in Table 5-16.

Table 5-16. Spacelab Flight Hardware Items

ELEMENT	COST (1977 $M)	ELEMENT	COST (1977 $M)
Core Module	35.0	Rack - Single	0.179
Igloo	10.0	- Double	0.229
IPS	10.0	EPDB	0.088
SIPS	1.5	Floor Segment	0.039
RAU	0.143		

As in the analysis of the other two traffic models, the determination of the Spacelab flight hardware requirements is governed principally by three major factors:

- involvement time of the Spacelab flight hardware in the ground processing flows of each option
- quantities required for a given payload configuration
- flight rate and launch schedule of the payload configuration for any given year of the traffic model

The configuration dependent Spacelab Flight hardware end items are illustrated in Table 5-17. The first two payloads Space Processing and Combined Astronomy are pallet only payloads and do not require habitable modules (Core Segment and Experiment Segment) nor do they require experiment racks. The last two payloads, the Life Science and the ATL, are habitable module payloads that would not require an Igloo.

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Table 5-17. Payload Spacelab Flight Hardware Requirements

Spacelab Hardware Element	Payload			
	S/P	C/A	L/S	ATL
Core Module	--	--	1	1
Igloo	1	1	--	--
IPS	--	1	--	--
Pallet Segment	1	5	--	2
RAU	1	9	4	4
Racks - Single	--	--	4	2
- Double	--	--	6	2
EPDB	1	5	3	3
Floor Segment	--	--	3	1
Cold Plates	4	5	--	4

The Life Science and ATL payloads do not utilize the SIPS nor the IPS as a part of their Spacelab flight hardware complement. The first four of these hardware end items (Core Module, Igloo, IPS and Pallet) are not as option-dependent as they are configuration-dependent. It has been established that these four end items would remain at KSC and not be shipped to an integration site for Level IV integration. These four end items become involved in the Spacelab ground processing flows at the appropriate time in the Level III/II integration operations in the O&C building. The variations in the total ground processing flows, at KSC, for each of these groups of payloads are so minor (2 pallet only CA and SP, 2 habitable module LS and ATL) that the quantities of these hardware end items required to support the 1/3 baseline traffic model are equal across all options evaluated in this study. Therefore, to establish the programmatic totals of Spacelab flight hardware the annual flight rate and launch schedules of the 1/3 baseline traffic model (shown in Table 5-18) must be the determining factors.

Table 5-18. 1/3 Baseline Traffic Model

PAYLOAD	YEAR											
	1980	81	82	83	84	85	86	87	88	89	90	91
LIFE SCIENCE	-	-	-	1	-	1	-	1	-	1	-	1
ATL	1	1	1	3	4	4	5	4	5	5	5	5
COMBINED ASTRONOMY	-	-	1	1	2	3	3	3	3	3	3	3
SPACE PROCESSING	-	1	1	2	2	3	3	3	3	2	3	2
TOTALS	1	3	3	7	8	11	11	11	11	11	11	11

It should be noted that while each of the last seven years of this traffic model have 11 flights, the distribution of these flights between the four payloads varies.

Derivation of Flight Hardware Quantities

The quantity of Core Modules required to support all options of the 1/3 Baseline traffic model is shown in Table 5-19 . As previously discussed in the section entitled "Spacelab Flight Hardware Requirements", at the present KSC assessed serial ground processing times a single Core Module can support up to six habitable module flights per year (given that the launches are at least 42 days apart. Therefore, from an inspection of the traffic model (Table 5- 1) and the launch dates (see section entitled "Personnel Requirements" of this volume), it can be seen that one Core Module would support all options. The utilization of that single Core Module would, however, be quite high averaging between 80 and 95% over the last seven years of the program.

Table 5-19 . Core Module Requirements for all Options (1/3 Baseline Traffic Model)

YEAR	FLIGHTS			TOTAL PROCESSING DAYS	UNITS REQ'D	% UTIL.
	LS	ATL	TOTAL			
1980	-	1	1	71	1	27.0
1981	1	1	2	106		40.8
1982	-	1	1	45		17.3
1983	1	3	4	164.0		63.0
1984		4	4	166.4		64.0
1985	1	4	5	205.6		79.1
1986		5	5	208.0		80.0
1987	1	4	5	205.6		79.1
1988		5	5	208.0		80.0
1989	1	5	6	247.2		95.1
1990		5	5	208.0		80.0
1991	1	5	6	247.2		95.1

The Igloo, SIPS and IPS requirements for all options of the 1/3 baseline traffic model are contained in Table 5-20. The study ground rule used in the establishment of the final SIPS and IPS program totals is, in the case of SIPS there would be an additional flight unit added to accommodate those missions planned to fly with two SIPS units. The IPS quantity requirements were modified by the ground rule that the IPS would only be used on every other Combined Astronomy type mission.

Table 5-20. Igloo, IPS, and SIPS Requirements for All Options (Baseline Traffic Models)

	Flts		Total	Igloo Units Req'd	Total Prog Days	% Util	Total Prog CA	SIP & IPS			
Yr	CA	SP						SIPS	% Util	IPS	% Util
1980	-	-	-								
1981	-	1	1	1	34.2	13.2					
1982	1	1	2		68.4	26.3	37.2	1+1	14.3	1	7.2
1983	1	2	3		102.6	39.5	37.2		14.3		7.2
1984	2	2	4		136.8	52.6	74.4		28.6		14.3
1985	3	3	6		205.2	78.9	111.6		42.9		21.5
1986	3	3	6		205.2	78.9					
1987	3	3	6		205.2	78.9					
1988	3	3	6		205.2	78.9					
1989	3	2	5		171.0	65.8					
1990	3	3	6		205.2	78.9					
1991	3	2	5	1	171.0	65.8	111.6	1+1	42.9	1	21.5

Spacelab Flight Hardware Requirements by Option

The following sections will define those hardware quantities for end items that are option dependent. These items are Racks, Pallet Segments, RAU's, Cold Plates, Floor Segments, and EPDB's. The Table 5-21 contains the Rack and Pallet requirement for each of the six options evaluated.

Table 5-21 . Rack and Pallet Requirements for All Options (1/3 Baseline Traffic Model)

Option	Equipment	Year											
		1980	81	82	83	84	85	86	87	88	89	90	91
A-1	Rack	2S 2D	4S 6D			6S 8D							
	Pallet	2	3	8		10							
A-3	Rack	2S 2D	4S 6D		6S 8D								
	Pallet	2	3	8	10								
B-1	Rack	2S 2D	4S 6D		6S 8D								
	Pallet	2	3	8	10								
B-4	Rack	2S 2D	4S 6D		6S 8D								
	Pallet	2	3	8	10								
C-1	Rack	2S 2D	4S 6D			6S 8D							
	Pallet	2	3	8		10							
C-4	Rack	2S 2D	4S 6D			6S 8D							
	Pallet	2	3	8		10							

Because of the relatively low flight rates of the model, the same amount of Spacelab flight hardware is required to support all six options the only differences between options are the actual year in which the equipment is required. In options A-1, C-1 and C-4, the final four racks (2 double and 2 single) and ATL flight rates climbs above 3 per year.

Table 5-22 lists the RAU, Cold Plate, and Floor Segment requirements for each of the six options.

Table 5-22. RAU, Cold Plate, and Floor Segment Requirements for all Options (1/3 Baseline Traffic Model)

Op-tion	Equipment	YEAR											
		1980	81	82	83	84	85	86	87	88	89	90	91
A-1	RAU	4	9	18		22							
	Cold Plate	4	8	13		17							
	Floor	1	3			4							
A-3	RAU	4	9	18		22							
	Cold Plate	4	8	13		17							
	Floor	1	3			4							
B-1	RAU	4	9	18		22							
	Cold Plate	4	8	13		17							
	Floor	1	3			4							
B-4	RAU	4	9	18		22							
	Cold Plate	4	8	13		17							
	Floor	1	3			4							
C-1	RAU	4	9	18		22							
	Cold Plate	4	8	13		17							
	Floor	1	3			4							
C-4	RAU	4	9	18		22							
	Cold Plate	4	8	13		17							
	Floor	1	3			4							

The quantities required to support all options are identical. The year in which the resources are required are also identical. At the flight rates of the 1/3 baseline traffic model there are no differences in the requirements for these three Spacelab hardware end items.

The EPDB's quantities for each option are illustrated in Table 5-23.

Table 5-23. EPDB Requirements for All Options (1/3 Baseline Traffic Model)

OPTION	YEAR											
	80	81	82	83	84	85	86	87	88	89	90	91
A-1	3	6	11		14							
A-3	3	6	11	14								
B-1	3	6	11	14								
B-4	3	6	11	14								
C-1	3	6	11		14							
C-4	3	6	11		14							

While all options require the same amount of EPDB's, three options A-1, C-1, and C-4 do not need their last 3 EPDB's until 1984 when the ATL launch rate increases and an additional 3 EPDB's are required to support this increased flight rate. Because of the shorter total ground processing time lines, the increase in flight rate is not felt in those three options until a later date.

Spacelab Flight Hardware Cost Summaries

The following six tables (Tables 5-24 thru 5-29) summarize the Spacelab Flight Hardware costs, including the year these costs were incurred, for each of the six program options. The costs of each hardware end item (study input) were allocated in the year preceding their first usage. Included in each table are the costs of each end item in 1977 dollars and also the escalated annual totals. The hardware end item costs were escalated using a 10% annual factor. The cost of each option in constant dollars (1977 $) are equal at 96.1 million. The launch rate and schedule of the 1/3 Baseline traffic model are not sufficiently high enough to provide a discriminator with respect to the quantities of flight hardware required. While it is true that the ground processing times of the KSC options (C-1 and C-4) are lower than that of other options, the flight rates evaluated in this model did not fully utilize the equipment to such an extent that differences between options would surface.

Table 5-24. Spacelab Hardware Costs
(1/3 Traffic Model)

OPTION A-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.358 .916	3.022	.715	.078	.108	.264	5.461	7.269
1981		15.110	1.287		.135	.440	16.972	24.847
1982								
1983	.358 .458	6.044	.572	.039	.108	.264	7.843	13.898
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.074 1.832	30.220	3.146	.156	.459	1.232	38.119	55.504

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Table 5-25. Spacelab Hardware Costs
(1/3 Traffic Model)

OPTION A-3	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.358 .916	3.022	.715	.078	.108	.264	5.461	7.269
1981		15.110	1.287		.135	.440	16.972	24.847
1982	.358 .458	6.044				.264	7.124	11 477
1983			.572	.039	.108		0.719	1.274
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.074 1.832	30.220	3.146	.156	.459	1.232	38.119	54.357

Table 5-26. Spacelab Hardware Costs (1/3 Traffic Model)

OPTION B-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	\$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.358 .916	3.022	.715	.078	.108	.264	5.461	7.269
1981		15.110	1.287		.135	.440	16.972	24.847
1982	.358 458	6.044				.264	7.124	11.477
1983			.572	.039	.108		0.719	1.274
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.074 1.832	30.220	3.146	.156	.459	1.232	38.119	54.357

Table 5-27. Spacelab Hardware Costs (1/3 Traffic Model)

OPTION B-4	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	\$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.358 .916	3.022	.715	.078	.108	.264	5.461	7.269
1981		15.110	1.287		.135	.440	16.972	24.847
1982	.358 .458	6.044				.264	7.124	11.477
1983			.572	.039	.108		.719	1.274
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.074 1.832	30.220	3.146	.156	.459	1.232	38.119	54.357

Table 5-28. Spacelab Hardware Costs
(1/3 Traffic Model)

OPTION C-1	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.358 .916	3.022	.715	.078	.108	.264	5.461	7.269
1981		15.110	1.287		.135	.440	16.972	24.847
1982								
1983	.358 .458	6.044	.572	.039	.108	.264	7.843	13.898
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.074 1.832	30.220	3.146	.156	.459	1.232	38.119	55.504

Table 5-29. Spacelab Hardware Costs
(1/3 Traffic Model)

OPTION C-4	RACKS	PALLETS	RAU	FLOORS	COLD PLATES	EPDB	TOTAL COST	
YEAR	.179S .229D	3.022	.143	.039	.027	.088	$77	ESCAL.
1979	.358 .458	6.044	.572	.039	.108	.264	7.843	9.490
1980	.358 .916	3.022	.715	.078	.108	.264	5.461	7.269
1981		15.110	1.287		.135	.440	16.972	24.847
1982								
1983	.358 .458	6.044	.572	.039	.108	.264	7.843	13.898
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
TOTALS	1.074 1.832	30.220	3.146	.156	.459	1.232	38.119	55.504

TRANSPORTATION COSTS

Transportation Factors

The transportation factors are identical to those discussed in the section "Transportation Factor" of this volume. The same type vehicle requirements exist, the same costing factors, and the same transportation times; however, these factors are balanced against the 1/3 traffic model.

For details as to these factors, refer to the appropriate discussions in Section 3.0 and 4.0.

Transportation Requirements

Similarly, as with the "Transportation Factors" discussed above, transportation requirements remain the same for the 1/3 traffic model. The cost of shipment of Spacelab flight and GSE hardware to/from Level IV integration sites other than at KSC were predicated upon the total number of end items and the width of the shipment. Shipments requiring an outsized carrier - greater than 8 feet in width - required five working days and cost $4000. Standard shipments of 8 foot in width were assumed to require two days and cost $3000. Shipments within the KSC complex were assumed to require one day and cost $1000.

In Section 3.0, Tables 3-82 through 3-85 summarize the transportation/shipment requirements and costs for each payload and their applicable processing options. Distributed site options are the most costly because of the duplication of out-sized carrier shipments. Lead center option costs reflect the feasibility of multiple out-sized elements contained in one shipment. As expected, KSC shipment costs are minimal.

Optimum Transportation Costs - 1/3 Traffic Model

The following six tables, Table 5-30 through 5-35 , are summaries of the transportation costs of the six options studied in detail: A-1, A-3, B-1, B-4, C-1 and C-4. Each of the tables summarize the studied options for each year and for the twelve year duration of the 1/3 mission model.

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Table 5-30. 1/3 Traffic Model

OPTION A-1	YEAR											
PAYLOADS	80	81	82	83	84	85	86	87	88	[illegible]	90	91	TOTAL
Combined Astronomy	-	-	42	42	84	126	126	126	126	12[illegible]	[illegible]	126	1050
Space Processing	-	15	15	30	30	45	45	45	45	30	[illegible]	[illegible]	375
Life Science	-	70	-	70	-	70	-	70	-	70	-	[illegible]	420
Advanced Technology	34	34	34	102	136	136	170	136	170	170	170	170	[illegible]462
TOTALS ($)	34	119	91	244	250	377	341	377	341	396	341	396	330[illegible]

Table 5-31. 1/3 Traffic Model

OPTION: A-3	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	-	-	45	45	90	135	135	135	135	135	135	135	1125
Space Processing	-	15	15	30	30	45	45	45	45	30	45	30	375
Life Science	-	70	-	70	-	70	-	70	-	70	-	70	420
Advanced Technology	34	34	34	102	136	136	170	136	170	170	170	170	1462
TOTALS ($)	34	119	94	247	256	386	350	386	350	405	350	405	3382

Table 5-32. 1/3 Traffic Model

OPTION. B-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	-	-	22	22	44	66	66	66	66	66	66	66	550
Space Processing	-	15	15	30	30	45	45	45	45	30	45	30	375
Life Science	-	17	-	17	-	17	-	17	-	17	-	17	102
Advanced Technology	14	14	14	42	56	56	70	56	70	70	70	70	602
TOTALS ($)	14	46	51	111	130	184	181	184	181	183	181	183	1629

Table 5-33. 1/3 Traffic Model

OPTION: B-4	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	-	-	22	22	44	66	66	66	66	66	66	66	550
Space Processing	-	15	15	30	30	45	45	45	45	30	45	30	375
Life Science	-	17	-	17	-	17	-	17	-	17	-	17	102
Advanced Technology	14	14	14	42	56	56	70	56	70	70	70	70	602
TOTALS ($)	14	46	51	111	130	184	181	184	181	183	181	183	1629

Table 5-34. 1/3 Traffic Model

OPTION: C-1	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	-	-	3	3	6	9	9	9	9	9	9	9	75
Space Processing	-	4	4	8	8	12	12	12	12	8	12	8	100
Life Science	-	3	-	3	-	3	-	3	-	3	-	3	18
Advanced Technology	3	3	3	9	12	12	15	12	15	15	15	15	129
TOTALS ($)	3	10	10	23	26	36	36	36	36	35	36	35	322

Table 5-35. 1/3 Traffic Model

OPTION C-4	YEAR												
PAYLOADS	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
Combined Astronomy	-	-	3	3	6	9	9	9	9	9	9	9	75
Space Processing	-	4	4	8	8	12	12	12	12	8	12	8	100
Life Science	-	3	-	3	-	3	-	3	-	3	-	3	18
Advanced Technology	3	3	3	9	12	12	15	12	15	15	15	15	129
TOTALS ($)	3	10	10	23	26	36	36	36	36	35	36	35	322

A summary table has been generated which details the various options studied with regard to the 1/3 Traffic Model based on the four study payloads, Table 5-36.

OPTION. The options which were studied in detail are A-1, A-3, B-1, B-4, C-1 and C-4. There is no option A-3 for Space Processing; however, option A-2 was studied in its place.

YEAR. The model time span was a 12-year period scheduled from 1980 through 1991.

COST PER FLIGHT-BASELINE. These are the costs in thousands of dollars as established in the section entitled "Transportation Requirements".

NUMBER OF FLIGHTS. For each payload studied, a total number of flights are identified based on the 1/3 Traffic Model for each year.

TOTAL TRANSPORTATION COSTS. The dollar amount in this column is a result of multiplying the number of flights times the transportation costs per flight (i.e., in 1984 there are 10 flights scheduled X 34(000) dollars = 340(000) dollars).

ALL PAYLOADS TOTAL. This is an accumulation of each payload's Total Transportation Cost column.

INFLATION FACTOR. An inflation factor was calculated for each of the years in the mission timeline based on an annual 7% compounded rate.

INFLATED COSTS. These are the final escalated transportation costs calculated by multiplying the straight totals by the inflation factor.

Table 5-36. Transportation Costs (1/3 Traffic Model)

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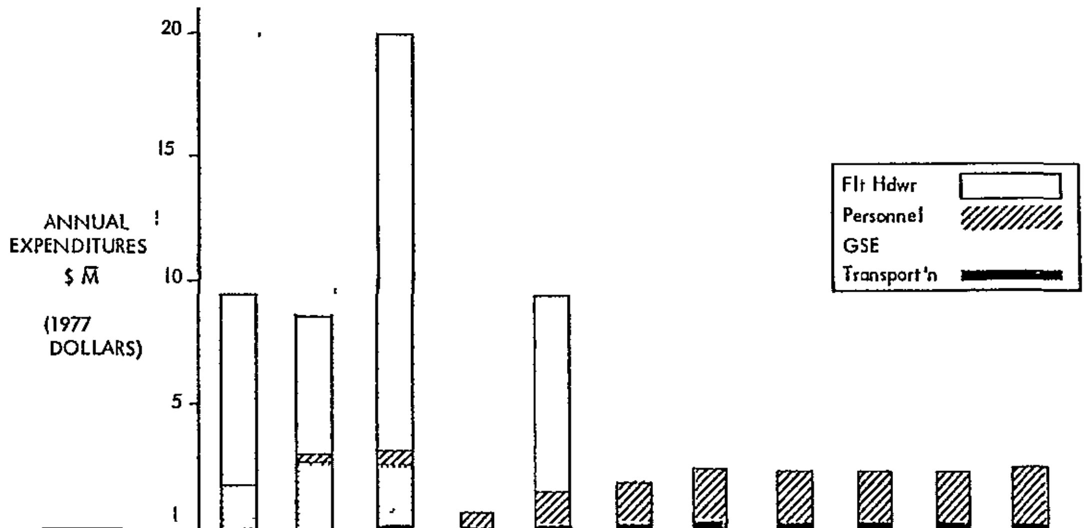
PAYLOADS		1/3 TRAFFIC MODEL														
		ATL			CA			LS			SP			TOTALS		
OPTION	YEAR	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	COST PER FLIGHT BASELINE ($K)	NUMBER OF FLIGHTS	TOTAL TRANSPORT COSTS ($K)	ALL TOTAL ($K)	INFLATION FACTOR	INFLATED COST ($K)
A-1	1980	34	1	34	42	-	-	70	-	-	15	-	-	34	1 225	41,65
	1981		1	34		-	-		1	70		1	15	119	1 311	156,01
	1982		1	34		1	42		-	-		1	15	91	1 403	127,67
	1983		3	102		1	42		1	70		2	30	244	1 501	366,24
	1984		4	136		2	84		-	-		2	30	250	1 606	401,50
	1985		4	136		3	126		1	70		3	45	377	1 718	647,69
	1986		5	170		3	126		-	-		3	45	341	1 838	626,76
	1987		4	136		3	126		1	70		3	45	377	1,967	741,56
	1988		5	170		3	126		-	-		3	45	341	2 105	717,81
	1989		5	170		3	126		1	70		2	30	396	2 252	891,79
	1990		5	170		3	126		-	-		3	45	341	2,410	821,81
	1991		5	170		3	126		1	70		2	30	396	2 579	1021 28
A-3 (A2 FOR SP)	1980	34	1	34	42	-	-	70	-	-	15	-	-	34	1 225	41,65
	1981		1	34		-	-		1	70		1	15	119	1 311	156,01
	1982		1	34		1	45		-	-		1	15	94	1 403	131,88
	1983		3	102		1	45		1	70		2	30	247	1 501	370 75
	1984		4	136		2	90		-	-		2	30	256	1 606	411,14
	1985		4	136		3	135		1	70		3	45	386	1 718	663 15
	1986		5	170		3	135		-	-		3	45	350	1 838	643 30
	1987		4	136		3	135		1	70		3	45	386	1 967	759 26
	1988		5	170		3	135		-	-		3	45	350	2 105	736 75
	1989		5	170		3	135		1	70		2	30	405	2 252	912 06
	1990		5	170		3	135		-	-		3	45	350	2,410	843,50
	1991		5	170		3	135		1	70		2	30	405	2 579	1044 49
B-1	1980	14	1	14	22	-	-	17	-	-	15	-	-	14	1,225	17,15
	1981		1	14		-	-		1	17		1	15	46	1,311	60,31
	1982		1	14		1	22		-	-		1	15	51	1,403	71,55
	1983		3	42		1	22		1	17		2	30	111	1 501	166 61
	1984		4	56		2	44		-	-		2	30	130	1 606	208 78
	1985		4	56		3	66		1	17		3	45	184	1,718	316 11
	1986		5	70		3	66		-	-		3	45	181	1 838	332,68
	1987		4	56		3	66		1	17		3	45	184	1 967	361 93
	1988		5	70		3	66		-	-		3	45	181	2 105	381 01
	1989		5	70		3	66		1	17		2	30	183	2 252	412 12
	1990		5	70		3	66		-	-		3	45	181	2 410	436,21
	1991		5	70		3	66		1	17		2	30	183	2 579	471,96
B-4	1980	14	1	14	22	-	-	17	-	-	15	-	-	14	1,225	17 15
	1981		1	14		-	-		1	17		1	15	46	1,311	60,31
	1982		1	14		1	22		-	-		1	15	51	1,403	71,55
	1983		3	42		1	22		1	17		2	30	111	1 501	166,61
	1984		4	56		2	44		-	-		2	30	130	1 606	208,78
	1985		4	56		3	66		1	17		3	45	184	1,718	316,11
	1986		5	70		3	66		-	-		3	45	181	1 838	332,68
	1987		4	56		3	66		1	17		3	45	184	1 967	361,93
	1988		5	70		3	66		-	-		3	45	181	2 105	381,01
	1989		5	70		3	66		1	17		2	30	183	2 252	412,12
	1990		5	70		3	66		-	-		3	45	181	2 410	436,21
	1991		5	70		3	66		1	17		2	30	183	2 579	471 96
C-1	1980	3	1	3	3	-	-	3	-	-	4	-	-	3	1,225	3,68
	1981		1	3		-	-		1	3		1	4	10	1 311	13,11
	1982		1	3		1	3		-	-		1	4	10	1,403	14,03
	1983		3	9		1	3		1	3		2	8	23	1,501	34,52
	1984		4	12		2	6		-	-		2	8	26	1 606	41,76
	1985		4	12		3	9		1	3		3	12	36	1,718	61,85
	1986		5	15		3	9		-	-		3	12	36	1 838	66,17
	1987		4	12		3	9		1	3		3	12	36	1,967	70,81
	1988		5	15		3	9		-	-		3	12	36	2,105	75,78
	1989		5	15		3	9		1	3		2	8	35	2,252	78 82
	1990		5	15		3	9		-	-		3	12	36	2 410	86 76
	1991		5	15		3	9		1	3		2	8	35	2 579	90,27
C-4	1980	3	1	3	3	-	-	3	-	-	4	-	-	3	1,225	3,68
	1981		1	3		-	-		1	3		1	4	10	1,311	13,11
	1982		1	3		1	3		-	-		1	4	10	1,403	14,03
	1983		3	9		1	3		1	3		2	8	23	1,501	34,52
	1984		4	12		2	6		-	-		2	8	26	1 606	41,76
	1985		4	12		3	9		1	3		3	12	36	1 718	61,85
	1986		5	15		3	9		-	-		3	12	36	1 838	66,17
	1987		4	12		3	9		1	3		3	12	36	1,967	70,81
	1988		5	15		3	9		-	-		3	12	36	2,105	75,78
	1989		5	15		3	9		1	3		2	8	35	2 252	78,82
	1990		5	15		3	9		-	-		3	12	36	2 410	86,76
	1991		5	15		3	9		1	3		2	8	35	2,579	90,27

e-4

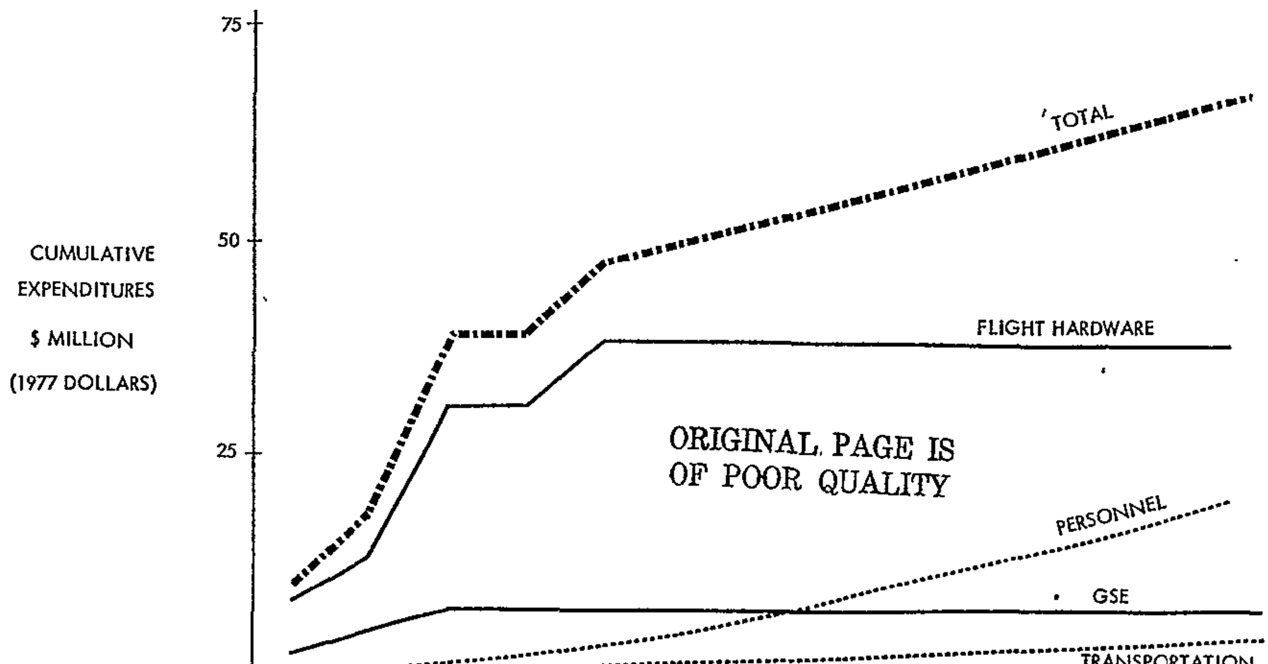
RESOURCE COST SUMMARY (1/3 BASELINE TRAFFIC MODEL)

This section summarizes the resource costs for all six options evaluated with the 1/3 Baseline traffic model. This section summarizes the costs developed for the four major resources areas: Spacelab Flight Hardware, Level IV "hands-on" personnel costs, Level IV Spacelab GSE, and Transportation costs. The launch schedule of the 1/3 Baseline Traffic Model builds up to a rate of 7 flights/year by the fourth year of the program (1987). The maximum flight rate is 11 flights/year. To support the launch schedule of this program, in all options, 91.8% of all the Spacelab flight hardware must be purchased by the third year of the program. This is illustrated on Figures 5-11 thru 5-12, These are the annual spending figures and the cumulative program resource requirements for each of the six options evaluated.



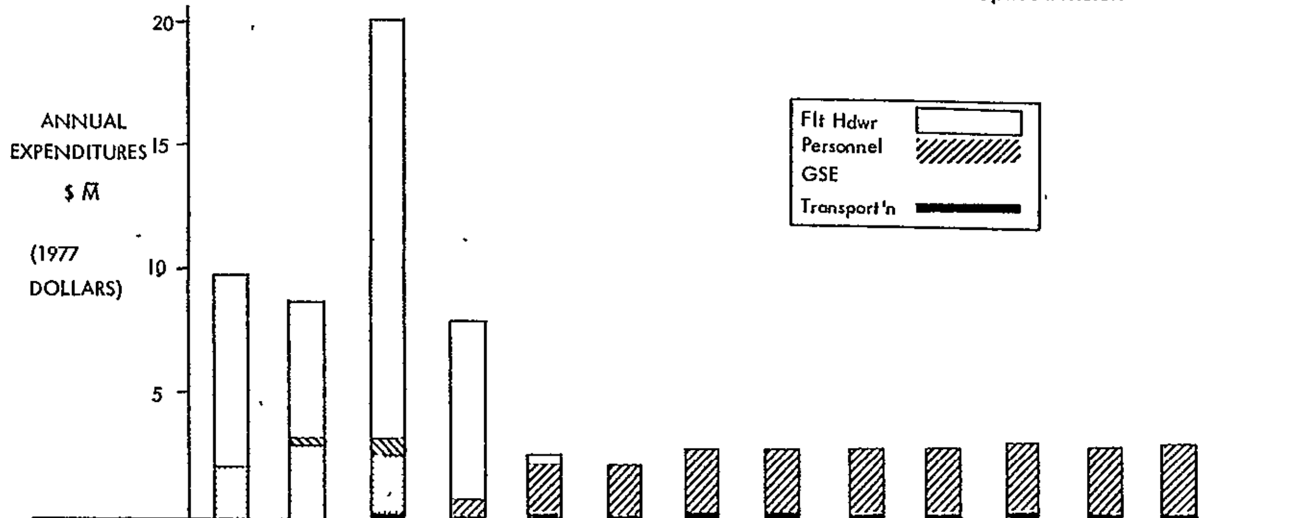
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	5.46	16 97	--	7.84	--	--	--	--	--	--	--	--	38.11
PERSONNEL	--	0.23	0.58	0.55	1.36	1.55	2.10	2.11	2.10	2.11	2.18	2.11	2.18	19.16
GSE	1.64	3.26	2.42	--	--	--	--	--	--	--	--	--	--	7.32
TRANSPORT'N.	--	0.03	0.12	0.09	0.24	0 25	0.38	0.34	0.38	0.34	0.40	0 34	0.40	3.31
TOTALS '77 $	9.48	8.98	20.09	0.64	9.44	1.80	2.48	2.45	2.48	2.45	2.58	2.45	2.58	67.90
ESCALATED $	11.35	11.24	28.93	0.90	17.21	2.90	4.25	4.50	4.86	5.15	5.80	5.90	6.54	109.53

Figure 5-1. Option A-1 Resource Summary (Annual Spending) (1/3 Traffic Model)



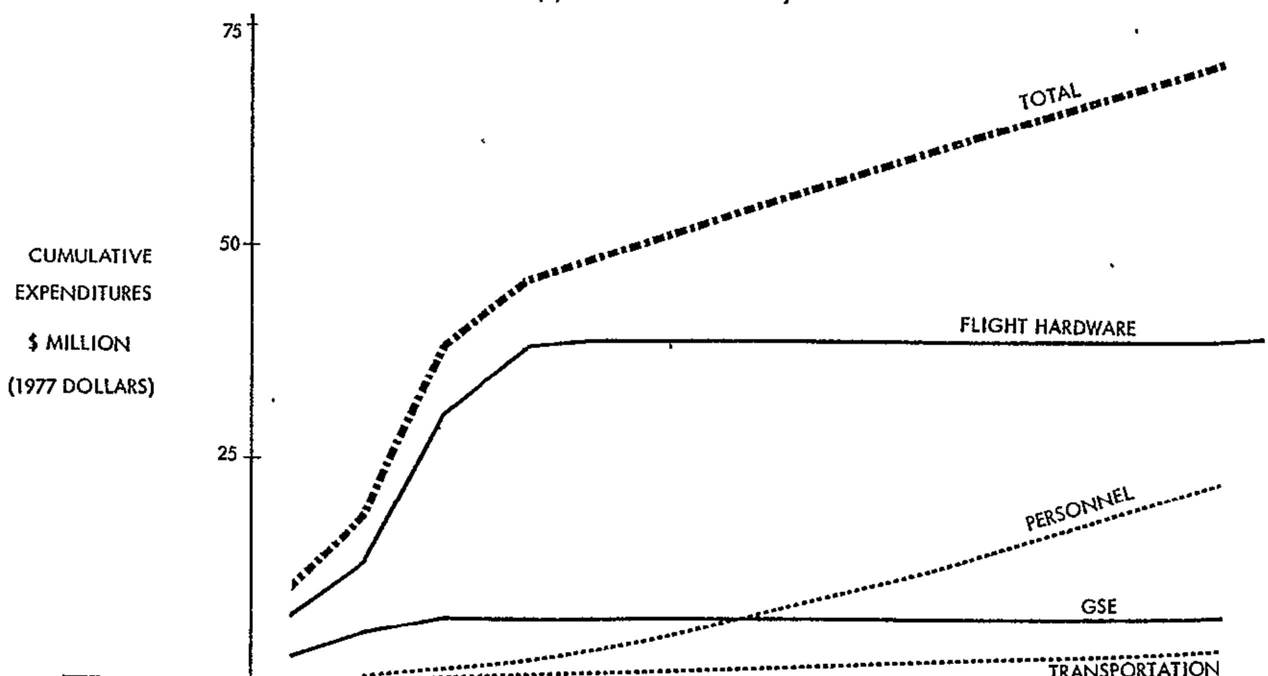
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	13.30	30.27	30.27	38.11								38.11
PERSONNEL	---	0.23	0.81	1.36	2.72	4.27	6.37	8.48	10.58	12.69	14.87	16.98	19.16
GSE	1.64	4.90	7.32										7.32
TRANSPORT'N.	---	0.03	0.15	0.24	0.48	0.73	1.11	1.45	1.83	2.17	2.57	2.91	3.31
TOTALS '77 $	9.48	18.46	38.55	29.19	48.63	50.43	52.91	55.36	57.84	60.29	62.87	65.32	67.90

Figure 5-2 . Option A-1 Resource Summary (Cumulative Spending) (1/3 Traffic Model)



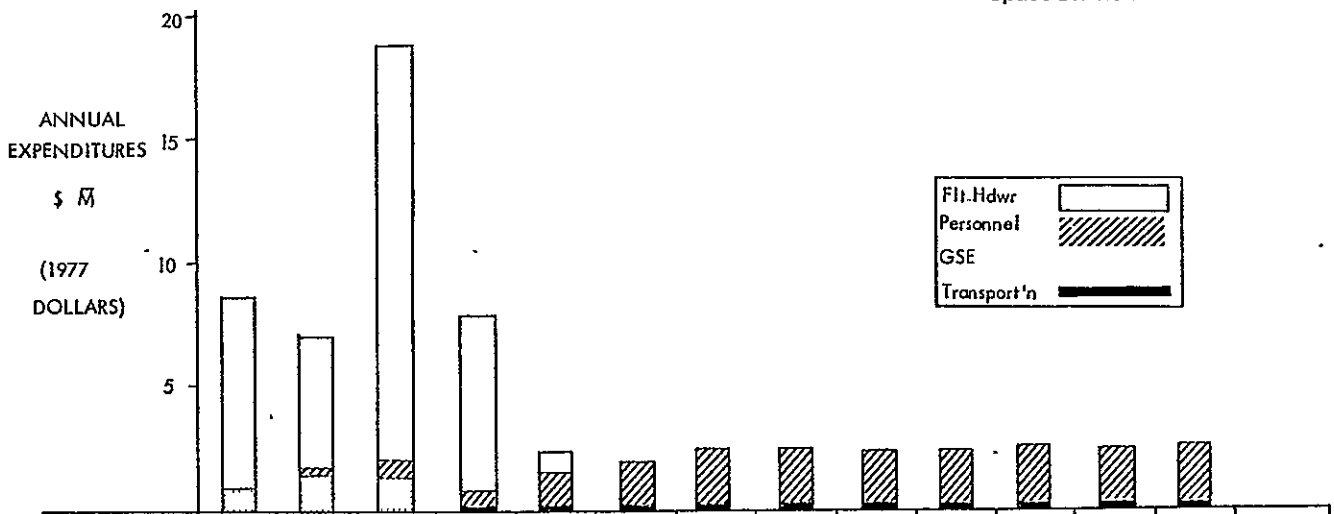
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	5.46	16.97	7.12	0.72	--	--	--	--	--	--	--	--	38.11
PERSONNEL	--	0.27	0.65	0 65	1.57	1.83	2.45	2.47	2.45	2.47	2.57	2.47	2 57	22.42
GSE	2.05	3.26	2.42	--	--	--	--	--	--	--	--	--	--	7.73
TRANSPORT'N.	--	0.03	0.12	0.09	0.25	0.26	0.39	0.35	0.39	0.35	0.41	0 35	0 41	3.40
TOTALS '77 $	9.89	9.02	20.16	7.86	2.54	2.09	2.84	2.82	2.84	2.82	2.98	2.82	2 98	71.66
ESCALATED $	11.84	11.29	29.02	12.52	3.99	3.34	4.87	5.19	5 58	5.95	6.70	6.80	7.68	114.77

Figure 5-3. Option A-3 Resource Summary (Annual Spending) (1/3 Traffic Model)



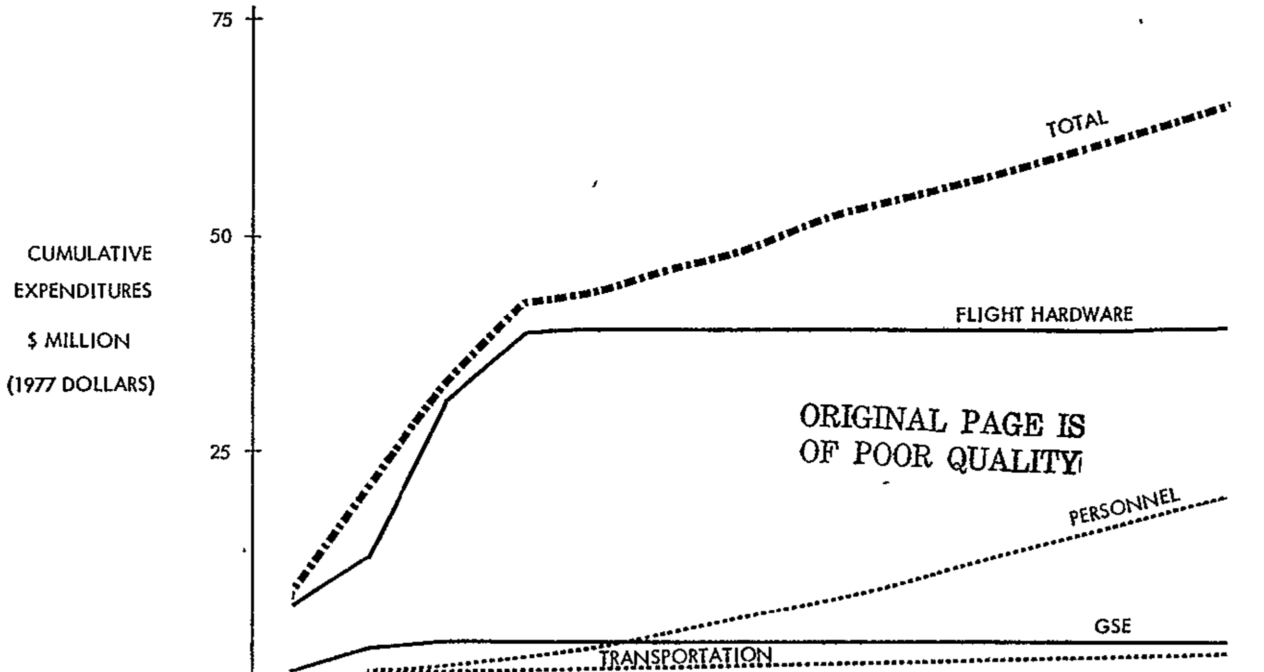
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	13.30	30.27	37.39	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11
PERSONNEL	--	0.27	0.92	1.57	3.14	4.97	7.42	9.89	12.34	14.81	17.38	19.85	22.42
GSE	2.05	5.03	7.45	7.45	7.45	7.45	7.45	7.45	7.45	7.45	7.45	7.45	7.73
TRANSPORT'N.	--	0.03	0.15	0.24	0.49	0.75	1.14	1.49	1.88	2.23	2.64	2.99	3.40
TOTALS '77 $	9.89	18.91	39.07	46.93	49.47	51.56	54.40	57.22	60.06	62.88	65.86	68.68	71.66

Figure 5-4. Option A-3 Resource Summary (Cumulative Spending) (1/3 Traffic Model)



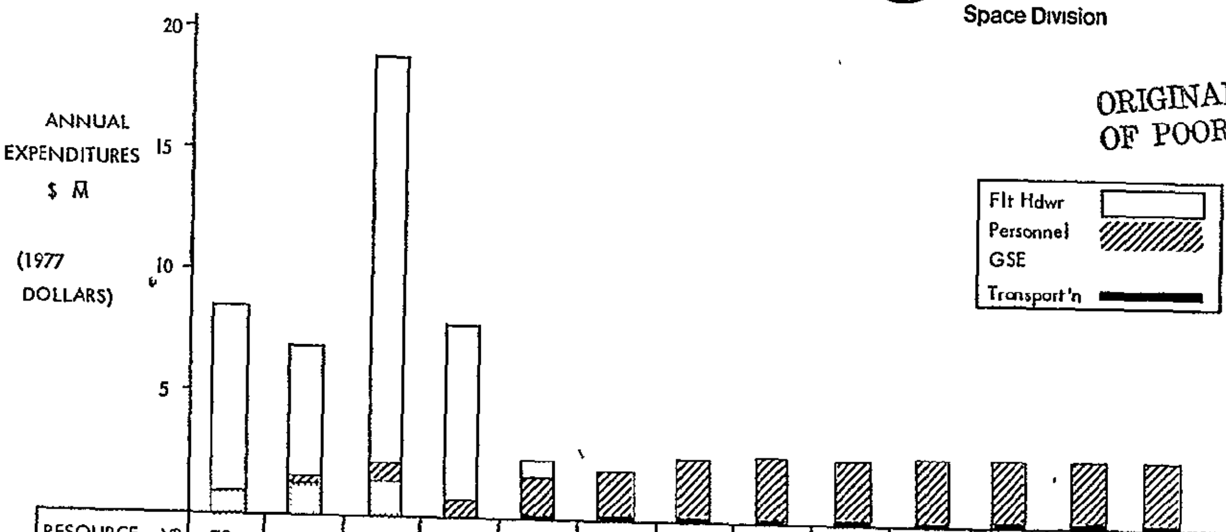
RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	5.46	16.97	7.12	0.72	--	--	--	--	--	--	--	--	38.11
PERSONNEL	--	0.24	0.59	0.59	1.42	1.66	2.21	2.25	2.21	2.25	2.30	2.25	2.30	20.27
GSE	0.83	1.32	1.25	--	--	--	--	--	--	--	--	--	--	3 40
TRANSPORT'N.	--	0.01	0 05	0.05	0.11	0.13	0.18	0.18	0.18	0.18	0.18	0.18	0.18	1.61
TOTALS '77 $	8.67	7.03	18.86	7.76	2.25	1.79	2.39	2.43	2.39	2.43	2.48	2.43	2.48	63.39
ESCALATED $	10.44	9.19	27.32	12.38	3.57	2.88	4.12	4.47	4.71	5.12	5.58	5.86	6.39	102.03

Figure 5-5. Option B-1 Resource Summary (Annual Spending) (1/3 Traffic Model)



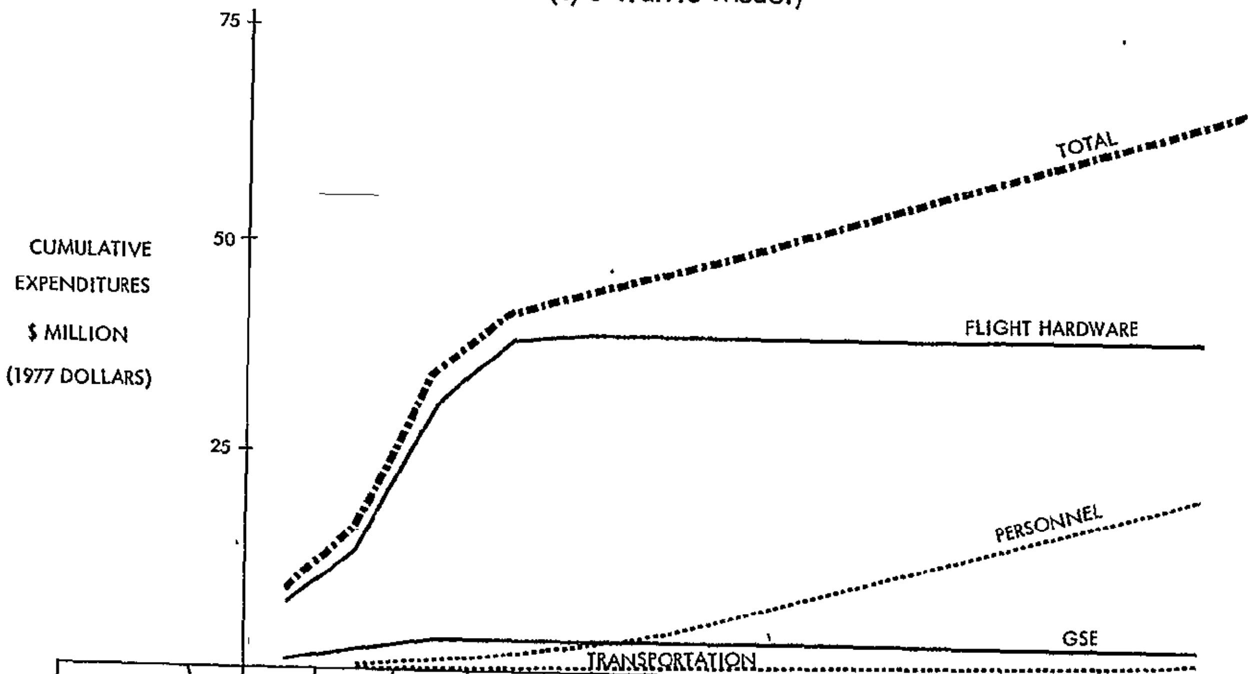
RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	13.30	30.27	37.39	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11
PERSONNEL	--	0.24	0.83	1.42	2.84	4.50	6.71	8.96	11.17	13.42	15.72	17.97	20.27
GSE	0.83	2.15	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40
TRANSPORT'N.	--	0.01	0.06	0.11	0.22	0.35	0.53	0.77	0.89	1.07	1.25	1.43	1.61
TOTALS '77 $	8.67	15.70	34.56	42.32	44.57	46.39	48.77	51.18	53.57	56.00	58.48	60.91	63.39

Figure 5-6 . Option B-1 Resource Summary (Cumulative Spending) (1/3 Traffic Model)



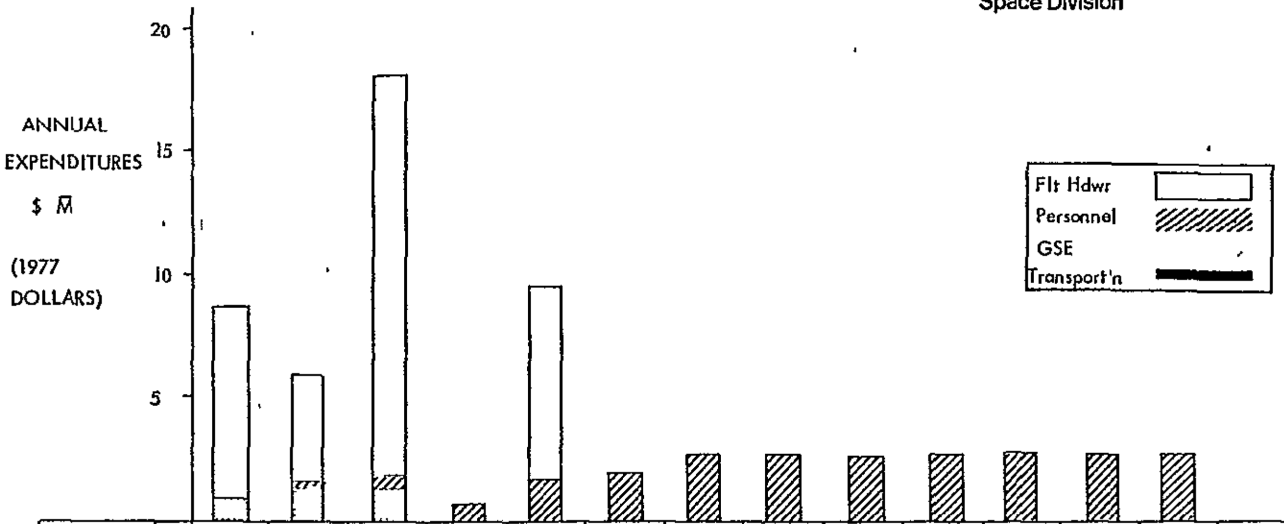
RESOURCE YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	5.46	16.97	7.12	0.72	--	--	--	--	--	--	--	--	38.11
PERSONNEL	--	0.25	0.60	0.61	1.47	1.73	2.29	2.34	2 29	2.34	2.38	2.34	2.38	21.02
GSE	0.79	1.18	1.21	--	--	--	--	--	--	--	--	--	--	3.18
TRANSPORT'N.	--	0.01	0.05	0.05	0.11	0.13	0.18	0.18	0.18	0.18	0 18	0 18	0.18	1.61
TOTALS '77 $	8.63	6.90	18.83	7.78	2.30	1.86	2.47	2.52	2.47	2.52	2.56	2.52	2.56	63.92
ESCALATED $	10.39	9.03	27.28	12.41	3.64	2.99	4.25	4.64	4.86	5.31	5.77	6.09	6.61	103.27

Figure 5-7. Option B-4 Resource Summary (Annual Spending)
(1/3 Traffic Model)



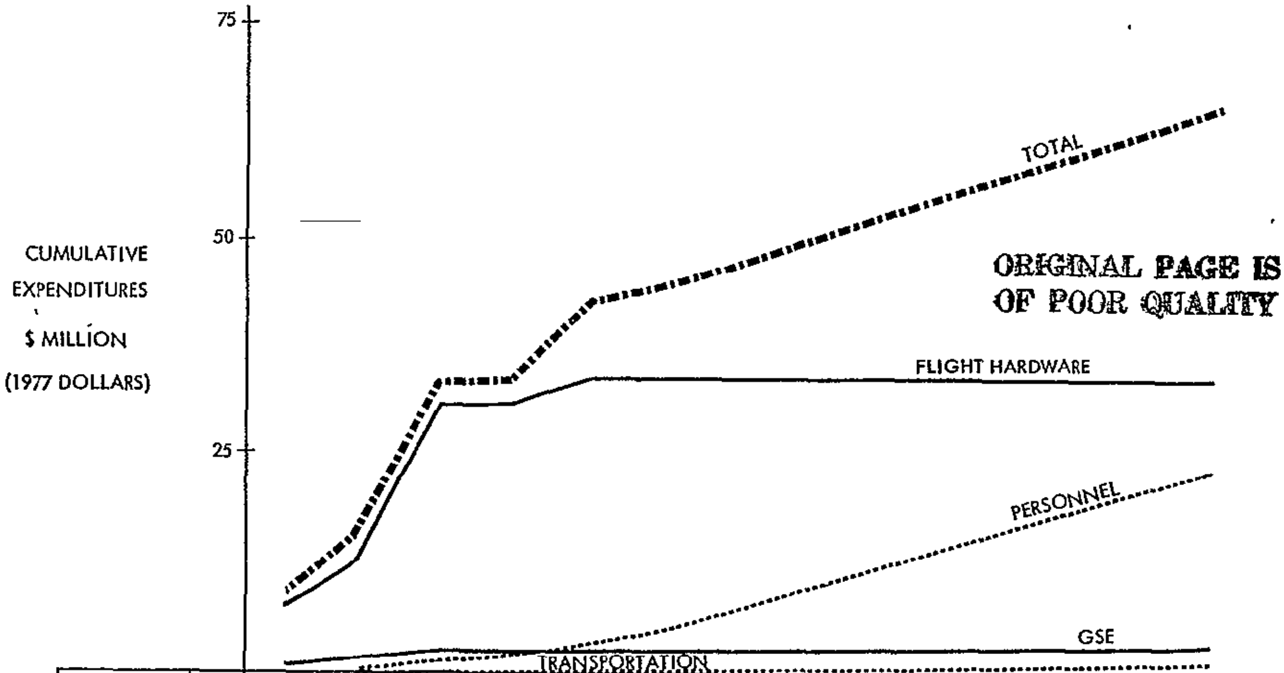
RESOURCE YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	13.30	30.27	37.39	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11
PERSONNEL	-	0.25	0.85	1.46	2.93	4.66	6.95	9.29	11.58	13.92	16.30	18.64	21.02
GSE	0.79	1.97	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
TRANSPORT'N.	-	0.01	0.06	0.11	0.22	0.35	0.53	0.71	0.89	1.07	1.25	1.43	1.61
TOTALS '77 $	8.63	15.53	34.36	42.14	44.44	46.30	48.77	51.29	53.76	56 28	58.84	61.36	63.92

Figure 5-8 . Option B-4 Resource Summary (Cumulative Spending)
(Traffic Model)



RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	5.46	16.97	--	7.84	--	--	--	--	--	--	--	--	38.11
PERSONNEL	--	0.26	0.66	0.68	1.60	1.89	2.53	2.57	2.53	2.57	2.62	2.57	2 62	23.10
GSE	0.83	0.25	0.51	--	--	--	--	--	--	--	--	--	--	1 59
TRANSPORT'N.	--	--	0.01	0.01	0 02	0.03	0.04	0.04	0 04	0.04	0.04	0.04	0.04	0 35
TOTALS '77 $	8.67	5.97	18.15	0.69	9.46	1.92	2.57	2.61	2.57	2.61	2.66	2.61	2.66	63.15
ESCALATED $	10.44	7.89	26.39	0.96	16.34	3.07	4.40	4.79	5.04	5.49	5.97	6.28	6.84	103.90

Figure 5-9. Option C-1 Resource Summary (Annual Spending) (1/3 Traffic Model)



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RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	13.30	30.27	30.27	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11
PERSONNEL	--	0.26	0.92	1.60	3.20	5.09	7.62	10.19	12.72	15.29	17.91	20.48	23.10
GSE	0.83	1.08	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
TRANSPORT'N.	--	--	0.01	0.02	0.04	0.07	0.11	0.15	0.19	0.23	0.27	0 31	0.35
TOTALS '77 $	8.67	14.64	32.79	33.48	42.94	44.86	47.43	50.05	52 61	55.22	57.88	60.49	63.15

Figure 5-10. Option C-1 Resource Summary (Cumulative Spending) (1/3 Traffic Model)

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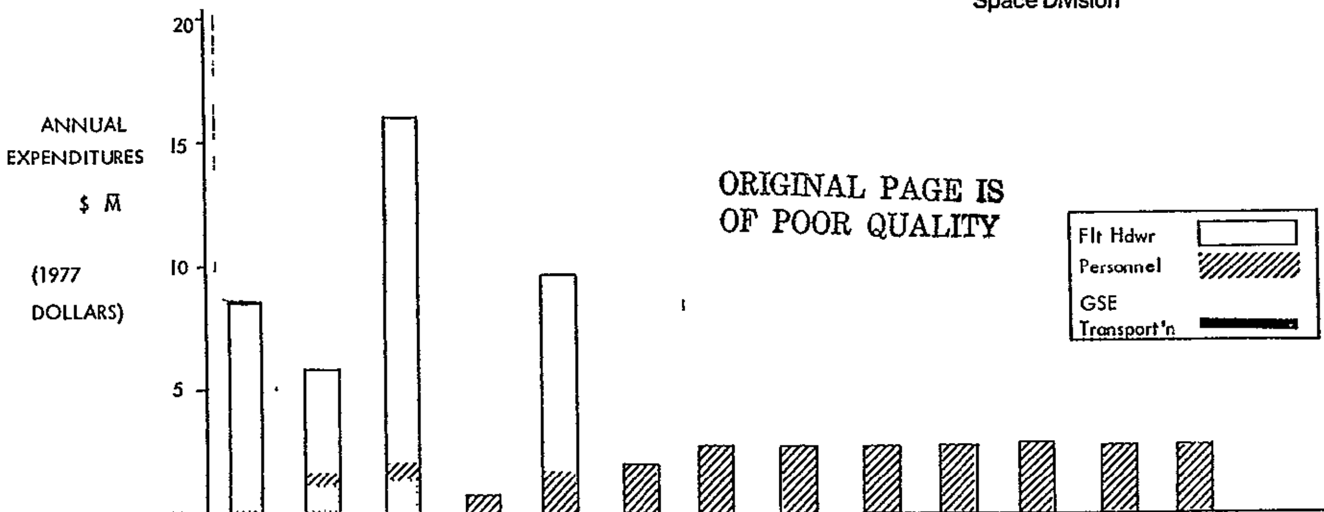
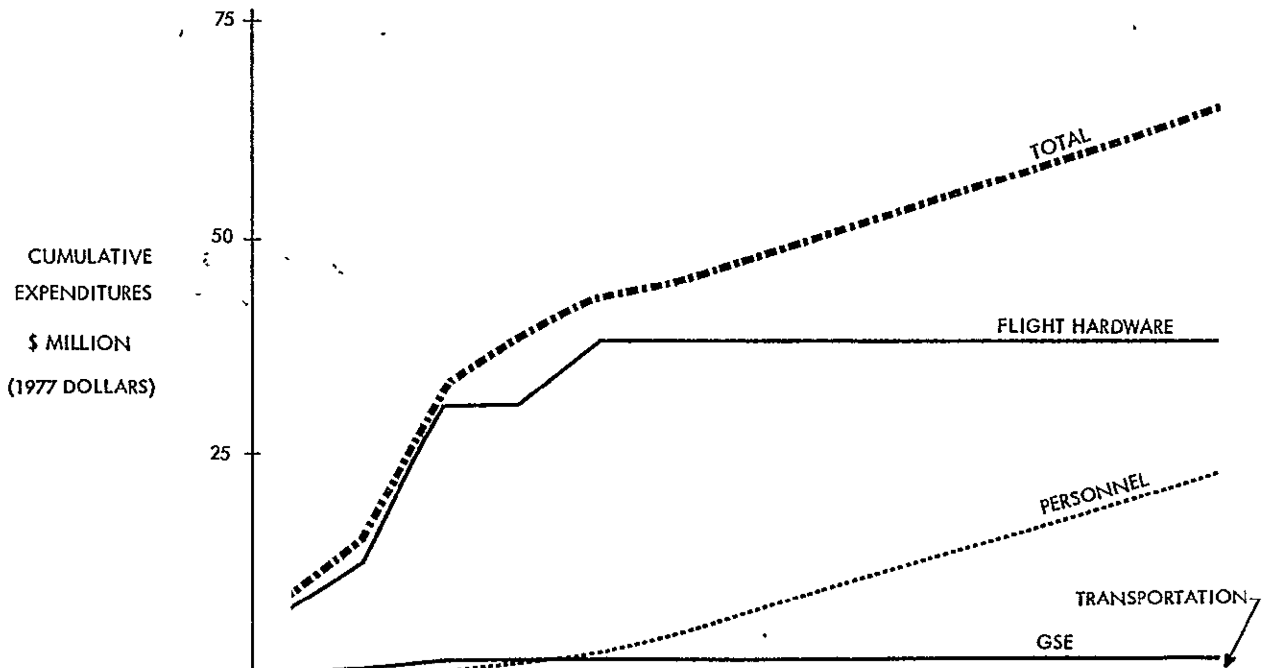


RESOURCE \ YR	79	80	81	82	83	84	85	86	87	88	89	90	91	TOTALS
FLT HDWE	7.84	5.46	16.97	--	7.84	--	--	--	--	--	--	--	--	38.11
PERSONNEL	--	0.29	0.69	0.70	1.67	1.97	2.61	2.67	2.61	2.67	2.71	2.67	2 71	23.97
GSE	0.79	0.11	0.54	--	--	--	--	--	--	--	--	--	--	1.44
TRANSPORT'N.	--	--	0.01	0.01	0.02	0 03	0.04	0.04	0.04	0.04	0 04	0.04	0.04	0 35
TOTALS '77 $	8.63	5.86	18.21	0.71	9.53	2.00	2.65	2.71	2.65	2.71	2.75	2.71	2.75	63.87
ESCALATED $	10.39	7.76	26.47	0.99	16.44	3.20	4.54	4.97	5.20	5.69	6.19	6.52	7 09	105.45

Figure 5-11. Option C-4 Resource Summary (Annual Spending)
(1/3 Traffic Model)



RESOURCE \ YR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
FLT HDWE	7.84	13.30	30.27	30.27	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11	38.11
PERSONNEL	--	0.25	0.98	1.68	3.35	5.32	7.93	10.60	13.21	15.88	18.59	21.26	23.97
GSE	0.79	0.90	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
TRANSPORT'N.	--	--	0.01	0.02	0.04	0.07	0.11	0.15	0.19	0.23	0.27	0.31	0.35
TOTALS '77 $	8.63	14.49	32.70	33.41	42.94	44.94	47.59	50.30	52.95	55.66	58.41	61.12	63.87

Figure 5-12. Option C-4 Resource Summary (Cumulative Spending)
(1/3 Traffic Model)

Table 5-37 contains the totals of the four resource categories for the six options evaluated. In this 1/3 Baseline Traffic Model, the lowest total option costs are for C-1 the KSC option with dependent experiment checkout and no combined payload checkout prior to Level III/II integration at the O&C building. Despite the high personnel costs, the transportation GSE and flight hardware costs for this program are the lowest of any of the six options and the resultant total is also the lowest. Since these options all require the same amount of Spacelab flight hardware, the total dollar (1977 $) differences for the other three resource categories are:

Option	Total *	Delta	%
C-1	25.14	—	—
B-1	25.41	.27	1.1
C-4	25.76	.62	2.5
B-4	25.81	.67	2.7
A-1	29.51	4.37	17.4
A-3	33.27	8.13	32.3

* for personnel, GSE, and Transportation only

Table 5-37. Summary of Option Costs (1977 $M)
(1/3 Baseline Traffic Model)

RESOURCE	OPTION					
	A-1	A-3	B-1	B-4	C-1	C-4
FLIGHT HARDWARE	96.11	96.11	96.11	96.11	96.11	96.11
PERSONNEL	19.16	22.42	20.21	21.02	23.10	23.97
GSE	7.04	7.45	3.40	3.18	1.60	1.40
TRANSPORTATION	3.31	3.40	1.74	1.61	0.35	0.35
TOTALS	125.62	129.38	121.52	121.92	121.16	121.83

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While the first four options are almost equal in cost, there does exist a 4 million dollar difference between these four and the distributed option A-1, and an 8 million dollar difference between A-3 and the four lowest.

At the lower flight rates of the 1/3 Baseline traffic model, the resouce requirements for the ground processing categories of "hands-on" Level IV personnel, the Level IV integration GSE and the Transportation cost totals are all relatively equal for the Centralized and the KSC options. These two sets of options are,however, less expensive than the distributed site options. Because of their lower total ground processing serial flow times, the KSC options would offer the additional advantage of utilizing less of the available total work days on the Spacelab flight hardware. The Combined Astronomy serial ground processing flow times for option C-1 are 53.9 working days. In option B-1, these same processing activities take 61.9 days, an 8 day difference. At the peak flight rate of the 1/3 Traffic Model (11 flights per year), there are 3 Combined Astronomy missions. The requirements of each option can be satisfied with one set of 5 pallet segments in either case. Therefore, for these missions, the Spacelab flight hardware costs for pallet segments would be identical. The processing times, however, would be 161.7 days total for option C-1 and 185.7 days for option B-1. This 24 day difference is not significant in that at 3 flights per year it does not add flight hardware equipment costs but it does reduce the ability of option B-1 to accommodate schedule slippages and contingencies. Also, option C-1 is capable of supporting a fourth C/A mission without any additional flight equipment (215.6 days processing time) and with some margin in its capacity. Option B-1 on the other hand will require 247.6 days out of the 250 available working days (99%) Thus, while the equipment requirements (at the launch rate of the 1/3 Baseline traffic model) are the same Option C-1 would have the advantage because of shorter ground processing flows, of tieing up the equipment and facilities less than any other option.

APPENDIX

APPENDIX

ACRONYMS AND ABBREVIATIONS LIST

Å	Angstrom
AAM	Ambient Air Monitor
AC	Alternate Current
ACCEL	Acceleration
AFD	Aft Flight Deck
AMP	Amplifier
ANAL	Analysis
ARC	Ames Research Center
ASSY	Assembly
ATL	Advanced Technology Laboratory
ATT	Attitude
AVG	Average
B/L	Baseline
BLKHD	Bulkhead
BRKT	Bracket
BSHF	Bio Science Holding Facility
BUP	Buildup
C	Centigrade
CA	Combined Astronomy
CACB	Center Aisle Connector Bracket
CB	Canister Bracket
CCTV	Closed Circuit Television
C/D	Controls/Displays
CDMS	Command and Data Management System
cg	Center of Gravity
CITE	Cargo Interface Test Equipment
CM	Centimeter
CMD	Command
C/O	Checkout
CNTR	Control
COAX	Coaxial
CONN	Connector
CORE	Common Operational Research Equipment
CPU	Control Processing Unit
CRT	Cathode Ray Tube
CRYO	Cryogenics
CS	Command/Control System
CTRL	Control
C&W	Caution and Warning
Dbl	Double
DC	Direct Current
DDU	Data Display Unit
DED	Dedicated
DEMOD	Demodulator
DEP	Dependent
DFP	Dedicatea Freon Pump
DIA	Diameter
DIFFER	Differential
DIST	Distribution
DWG	Drawing
DYN	Dynamics
E	Engineer
ECG	Electrocardiogram
ECS	Environment Control System
EDP	Experiment Definition Package
EGRET	Explore Gamma Ray Experiment Telescope
EI	End Item
EKG	Electrocardiogram
EL	Electrolite
EMI	Electromagnetic Interference
EOG	Oculographic
EPDB	Experiment Power Distribution Box
EPSP	Experiment Power Switching Panel
ES	Electrical/Environment System
EXP	Experiment
EXPMT	Experiment
FACL	Facility
FILT	Filter
FLT	Flight
FOV	Field of View
FSS	Flight Support System
FSS	Forward Support Structure
FT	Foot, Feet
FUNCT	Function
FURN	Furnish
FWD	Forward
FZR	Freezer
g	Gravity
GE	General Electric
GN_2	Gaseous Nitrogen
GPR	Ground Processing Requirements
GSE	Ground Support Equipment
GSR	Ground Support Requirements
HDWE	Hardware
HDRM	High Data Rate Multiplexer
HE	Heat Exchanger
He	Helium
HF	Holding Facility
Hr	Hour
HV	High Voltage
Hz	Hertz
ICRS	Intercomm Remote Station
IMU	Inertial Measurement Unit
In	Inch
IND	Independent
INT	Integrated
INVERT	Inverter
INSTAL	Installation
INV/V	Involvement
IR	Infrared
IRU	Inertial Reference Unit
I/O	Input/Output
IPS	Instrument Pointing System
I/S	Interconnect Station
IVT	Intraventricular
JC	Jettison Cable
JSC	Johnson Spaceflight Center
K	Kelvin
Kg	Kilogram
KSC	Kennedy Spaceflight Center
LBNP	Lower Body Negative Pressure
LG	Large
LGHE	Liquid/Gas Heat Exchanger
LHe	Liquid Helium
LN2	Liquid Nitrogen
L/S	Life Science
m	Meter
MEAS	Measure
MECH	Mechanism, Mechanical
MEGRD	Medium Energy Gamma Ray Detector
MET	Metered
Mev	Million Electron Volts
MIC	Multiple Instrument Compartment
MISC	Miscellaneous

mm	Milimeter
MOD	Module
M/P, MP	Manpower
MPF	Multipurpose Furnace
MS	Mass Spectrometer
MSS	Mission Specialist Station
MTRS	Meters
OAF	Orbiter Aft Flight
O&C	Operations and Checkout
OEM	Orbital Environment Monitor
OFLA	Off-line Assembly
ONLA	On-line Assembly
OPF	Orbiter Processing Facility
OPS	Operations
OSC	Osciloscope
OSCILL	Oscilloscope
PC	Power Cable
PDB	Power Distribution Box
PI	Principal Investigator
P/L	Payload
PMT	Photomultiplier Tube
PNL	Panel
POS	Position
PSS	Payload Special Station
PWR	Power
RAD	Radius
RAU	Remote Acquisition Unit
RBC	Red Blood Cell
RCS	Reaction Control System
RCVR	Receiver
REC	Recorder
Red	Reduction
RESPIR	Respiration
r f.	Radio.Frequency
R.O.	Read Out
SC	Signal Cable
SCINT	Scintilator
SEG	Segment
SHe	Super Critical Helium
SIG	Signal
SIPS	Small Instrument Pointing System
SIRTF	Shuttle Infrared Telescope Facility
S/L	Spacelab
SP	Space Processing
SPAR	Space Processing Application Rocket
SPECT	Spectrometer
SSUS	Solid Spinning Upper Stage
STBD	Starboard
STS	Space Transportation System
SUB	Substitute
SURV	Survey
T	Technician
TDY	Temporary Duty
TELE	Telescope
TLM	Telemetry
TRANS	Transportation
UV	Ultraviolet
VERIF	Verify, Verification
VAC	Voltage Alternating Current
VDC	Voltage Direct Current
XMTR	Transmitter
XPORT	Transport